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ORIGINAL ARTICLES.

I.—Note on *Eophyton* ? *explanatum*, Hicks, and on *Hyalostelia* (*Pyritonema*) *fasciculus*, M'Coy, sp.

By George Jennings Hinde, Ph.D., F.G.S.

Mr. W. Carruthers, F.R.S., lately called my attention to the resemblance between some drawings I was showing to him of *Hyalostelia fasciculus*, M'Coy, sp., and the supposed fossil plant, described and illustrated by Dr. Henry Hicks, F.R.S., in the Geological Magazine for 1869, Vol. VI. p. 534, Pl. XX. Figs. 1*a–e*, under the name of *Eophyton* ? *explanatum*.

The following is the description given by Dr. Hicks of this fossil: "A raised moderately convex stem about four lines in breadth; widening however and becoming somewhat compressed at the joints. The surface is ribbed and furrowed along its whole length. At the lower joints, the ribs bend outwards, evidently to form a branch. The joint is obliquely placed, widened out, and its course distinctly marked by a deep sulcus. The cortical substance is very thin, and can be removed to show the internal structure. The internal structure is made up of compressed columns, running the whole length from joint to joint, evidently of a tubular nature, and bound together by very thin tissue."

Owing to the fact that no structure had been discovered in the type forms of the genus *Eophyton*, Dr. Hicks placed this fossil only provisionally under the genus, but he at the same time stated that there could be no reasonable doubt of its vegetable nature, and that its affinity to the vascular cryptogams was most clearly shown.

Its plant-characters, however, were not acknowledged by Mr. Carruthers, who wrote respecting it: "It is very doubtful whether this fossil belongs to the Vegetable Kingdom. The large-sized continuous tubes of which it is composed are unlike plant-structure" (Seemann's Journal of Botany, vol. viii. p. 13).

Subsequently, in the Quarterly Journal Geol. Soc. for 1881, vol. 37, p. 490, Dr. Hicks again refers to the same fossil in the following paragraph: "Of *Eophyton* ? *explanatum*, which I found in the Tremadoc rocks of St. David's, I fear the evidence is scarcely sufficient to ally it with land-plants. Its strong tubular structure renders it unlike any known land-plant; and the only other fossil found yet, to which it can be compared, is the *Pyritonema* of Prof. M'Coy, placed by him

amongst the Zoophytes, though its true nature is still a matter of much doubt."

Being desirous of ascertaining the true character of *Eophyton explanatum*, I applied to Dr. Hicks, who very kindly at once forwarded to me the original specimen, as well as two microscopic sections which had been prepared from it, and these very distinctly showed that Dr. Hicks was quite correct in his later comparison of the fossil to the *Pyritonema* of M'Coy. I have also been enabled to compare it with the type specimen of *Hyalostelia* (*P.*) *fasciculus*, M'Coy, belonging to the Cambridge Woodwardian Museum, which was kindly lent to me by Prof. T. McKenny Hughes, and also with examples of the same species in the British Natural History Museum, the Jermyn Street Museum, and others kindly forwarded to me by Mr. G. H. Morton, F.G S., from Pont Ladies, Llandeilo.

Dr. Hicks's specimen is shown on the fractured surface of a slab of hard black shale, which, judging from the distorted forms of the Brachiopods in it, must have been strongly compressed. It has the appearance of an elongated, slightly convex band with delicate longitudinal striæ or ribs. The band, which is about 5·5 mm. in width and 1·5 mm. in thickness, can be traced continuously in a nearly straight direction throughout the slab; in one place it is slightly bent and traversed obliquely by an incomplete fracture, which was supposed by Dr. Hicks to be a joint in the stem, but which probably arises from compression in the rock. The band, for some distance, is enveloped by a thin coating of the shaly matrix, supposed to have been a cortical tissue; where this is absent, the constituent spicular rods are clearly exposed.

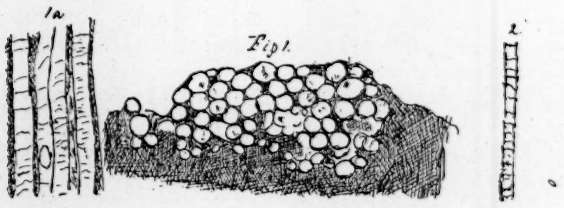


Fig. 1. *Eophyton? explanatum*, Hicks = *Hyalostelia fasciculus*, M'Coy, sp. Transverse section of the bundle of spicular rods. From Dr. Hicks's type-specimen.
,, 1*a*. The same, showing longitudinal sections of some of the rods.
,, 2. A single spicular rod of *Hyalonema mirabile*, Gray. The figures are all drawn to the same scale of eight diameters.

The apparent band is, in fact, a bundle of solid, elongated, cylindrical spicular rods, disposed parallel to each other, and for the most part in close contact, but without any organic connection with each other. In some instances the rods are compressed together so as to become partially flattened, but originally they appear to have been circular in transverse section. The minute interspaces occasionally intervening between the rods are filled by the rock-matrix, and there

are no traces of any enveloping structure inclosing the bundle. The rods vary from ·15 to ·5 mm. in thickness, they are now of chalcedonic silica, and for the most part solid throughout, in only a single instance did I see an indication of an axial canal. Delicate wrinkled lines cross the rods transversely and apparently represent the slight projecting frills met with in other specimens.

In all important characters, Dr. Hicks's specimen so closely resembles the typical example of *Hyalostelia* (*Pyritonema*) *fasciculus*, M'Coy,[1] that there is no reason to regard it as specifically distinct. The individual rods do not reach the maximum thickness of some of those in the typical form of the species, but the differences are not so great as to be of specific value.

Having established the similarity between these forms, it is desirable to point out that the relationship, indicated by M'Coy, of *Pyritonema fasciculus* to the glass-rope of *Hyalonema mirabile*, Gray, is of a genuine character. This has been called in question, amongst others, by Prof. G. Lindström,[2] who states that M'Coy's species "is nothing but a silicified and consequently somewhat altered *Heliolites*. It must be confessed that the purely diagrammatic figure given by M'Coy (Brit. Pal. Foss. pl. i. *B*, fig. 13*a*) might readily give rise to this conclusion. Prof. F. Roemer[3] also states that the systematic position of the genus, in which species allied to the present one are placed, is very uncertain. I also found the specimens of this species in the Jermyn Street Museum, placed with the Annelida of the Llandeilo group, probably on account of their close resemblance to *Hyalostelia* (*Serpula*) *parallela*, M'Coy, sp., from which they can hardly be distinguished.

At the time when M'Coy compared *Pyritonema fasciculus* with the rope of *Hyalonema mirabile*, Gray, the true sponge nature of this latter form was stoutly denied by Dr. Gray, who then regarded the rope as the skeleton of a Zoophyte, and M'Coy also adopted this opinion. It is now well known that ropes or tufts of long spicular rods are common appendages in many of the deep-sea hexactinellid sponges, and the resemblance of these to the fossil forms is very striking.

In both recent and fossil examples there is a similar form and arrangement of the spicular rods in bundles; the rods correspond in dimensions, in their siliceous composition, and, when the fossil forms are well preserved, in the possession of axial canals, and even the concentric layers of the rods can be seen. In some species, though not in the present one, some of the fossil rods terminate in four recurved hooks, precisely as in the recent examples. In another structural feature also, which has not hitherto been particularly noticed, there is a well-marked correspondence between *Hyalostelia fasciculus* and the recent *Hyalonema mirabile*. This is the occurrence, on the surface of some of the rods, of minute annular or spiral projecting ridges or frills, which look like so many wrinkled lines crossing the rods. The frilled rods are irregularly interspersed in the same bundle with

[1] Brit. Pal. Foss. p. 10, pl. i. *B*. fig. 13.
[2] Bih. till K. Svenska Vet. Akad. Handl. Bd. 8, No. 9, 1883, p. 13.
[3] Lethæa Palæozoica, 1880, p. 318.

others having smooth, even surfaces, in some cases most of the rods are provided with frills, whilst in others there is only about one in ten or twenty with them. In the recent *Hyalonema mirabile* some of the spicular rods are also provided with projecting spiral fringes of a similar character to those in the fossil form, but when perfect the frills are armed with minute spines.

At present, definite hexactinellid spicules have not been found in the same strata with *H. fasciculus*, but this negative fact can hardly be employed as an argument against the sponge-character of the spicular bundles. As these latter were, in the life-time of the sponge itself, imbedded in the muddy bottom of the ocean, they were not liable to be disturbed and dispersed after the death of the animal, in the same manner as those of the body of the sponge, and this same fact will also account for the preservation of the ropes or bundles of spicules with their constituent spicular rods in their natural positions.

The specimen discovered by Dr. Hicks in the Tremadoc rocks of Wales thus establishes the presence of siliceous hexactinellid sponges with anchoring appendages of bundles of spicular rods, at this horizon, and the same species also occurs at Trefil and at Pont Ladies in the Llandeilo rocks.

Allied species of *Hyalostelia* are recorded by Nicholson[1] and Etheridge from Ordovician strata in the Girvan area; by Prof. Ferd. Roemer[2] from Lyckholm strata (= Bala) in Esthland, and in the drift of Sadewitz;[3] and they are very abundant in Lower Carboniferous beds in Scotland, Ireland, and Yorkshire.

The genus *Hyalostelia*, in which the *Pyritonema fasciculus*, M'Coy, is now placed, was proposed by Zittel[4] to include sponges, with an upper portion of regular hexactinellid spicules and an anchoring appendage of elongated spicular rods.

In conclusion mention may be made that Dr. Hicks has presented his original specimen to the British Natural History Museum.

II.—On a New Species of *Axosmilia* (*A. elongata*) from the Pea Grit of the Inferior Oolite of England.

By Professor P. Martin Duncan, M.B. (Lond.), F.R.S., etc.

MANY years since, Mr., now Prof., Ralph Tate gave me a small slender coral, which he had obtained from the Pea Grit of the West of England. I had just completed the Supplement to the British Fossil Corals, Pal. Soc., so the fossil has remained undescribed.

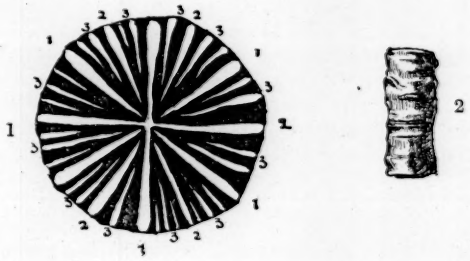
It has lately been determined to publish a new edition of the late Prof. J. Morris's Catalogue of British Fossils, and therefore, in order to render the Madreporarian part of that work as complete as is possible, I have studied and now describe the species.

The specimen is well preserved, except in the calice, but the deficiency is compensated by an excellent section close below.

The narrow peduncle of the form has been broken from its attachment, and there are no structures which denote that the form was

[1] Mon. Sil. Fos. Girvan, fasc. ii. p. 239, pl. xix. figs. 1–1*b*.
[2] Lethæa palæozoica, 1880, p. 318.
[3] Foss. Fauna von Sadewitz, p. 55, pl. vii. figs. 7*a*, 7*b*.
[4] Handbuch der Pal. vol. i. p. 185.

otherwise than a simple, tall individual, attached, like many simple corals, to a foreign body. The epitheca is strong, and, as is usual in the genus, is remarkably ringed with *bourrelets d'accroissement*, or growth-rings, so that the surface is tumid and constricted consecutively about thirteen times in the height of 37 mm. No abrasion of the epitheca has occurred, and there are therefore no septa to be seen on the flanks of the coral from wearing in. The inside of the coral is filled with a brown homogeneous calcite, and the septa and columella are white in colour. The condition of preservation is very fair, but it appears that some destructive action proceeded, for a septum of the fourth order is missing here and there, a fifth being present.



Axosmilia elongata, sp. nov., Pea Grit, West of England. 1. Transverse section (enlarged five times). 2. Interior (natural size).

Axosmilia elongata, sp. nov.— Corallum simple, tall, straight, cylindrical, with a small peduncular attachment which leads upwards to a conico-cylindrical stem, terminating in a cylindrical top; diameter one-fifth of the height.

Epitheca strong, marked with narrow rings and alternate swellings and constrictions. Wall merging into the epitheca, epithecate wall thin. Calicular section nearly circular in outline.

Septa well developed, eight long and stout reaching the small, essential, styloid, slightly compressed columella. Six of these are primaries and two are secondaries, the other secondaries being smaller. Tertiary septa long, slender, and often having a paliform knob at the inner end, not always straight. The higher orders are small and somewhat irregularly developed (unless absorption of some others has taken place). The bases of the septa at the thin wall are large, and the laminæ become slender towards the columella. Probably the correct cyclical arrangement is four systems with four cycles, and two systems with three cycles and part of a fourth, but the following can be seen.

Two systems with three cycles of septa and one septum of the fourth order in each. Two systems with four cycles complete, the fourth and fifth orders of the fourth cycle being placed as is usual in other Madreporaria. A system with three cycles and two members of a fourth cycle, but in one half-system there is a septum of the fourth order, and in the other half-system there is no septum of the

fourth, but there is one of the fifth order; this being anomalous, it is probable that the fourth order of the half-system has been lost.

A system with three cycles complete and the fourth cycle represented by septa of the fourth and fifth orders in one half and by a septum of the fourth order only in the other half-system.

Endotheca scanty. Costæ absent. Height 37 mm. Breadth of section 6 mm.

The distinctness of the species from *Axosmilia Wrighti*, Ed. & H., is evident; but the incomplete cyclical arrangement of the septa allies the species to *A. extinctorium*, Mich., sp. The tertiary septa of this last species are said by Ed. & Haime to unite with the secondaries close to the columella; this does not occur in the new form, which moreover has little knobs resembling paliform lobes at the inner ends of some septa as seen in the section.

The question arises almost of necessity, Was this coral a solitary or simple form? The straight shape, the absence of lateral adhesion markings, and the deficiency of any gemmation, indicate the simple nature; moreover, there are no signs of continuity between the base of the specimen and a parent stem. Nevertheless, it must be remembered that certain fasciculate corals might present pieces of a shape similar to the new form; but no one has been found with the special characters of the calicinal section described above. It appears that Milne Edwards and Jules Haime were correct in placing *Axosmilia* amongst simple corals; but the present species is more elongate and less expanded superiorly than their type. The new form differs from all others, and from all parts of forms which have been described from the Lower Oolite series.

The specimen is now in the British Museum.

III.—Mesozoic Angiosperms.

By J. S. Gardner, F.G.S.

(PLATE IX.)

SINCE the article on Mesozoic Angiosperms was written,[1] a very important Sketch History of "Palæobotany," by Lester F. Ward, has appeared in the Fifth Annual Report of the U. S. Geol. Survey, a brief outline of which cannot fail to prove of interest in connexion with this subject. The object of the sketch is to collate and reduce the fragmentary and desultory mass of information collected by previous writers into a system that will enable geologists to use the testimony of fossil plants, in the same way that they habitually use that of fossil animals. The author laments that botanists and palæobotanists have worked and classified almost wholly independently of each other, the former having consequently missed such important data for classification as the order in time in which each type appeared, while the latter have failed to harmonize their work with the more elaborate and best botanical systems, and hence greatly lessened its practical value. "Every candid palæobotanist must admit that he can understand fossil plants only as they resemble living ones, and that the botanist, studying the per-

[1] See Geol. Mag., May, 1886, pp. 193-204.

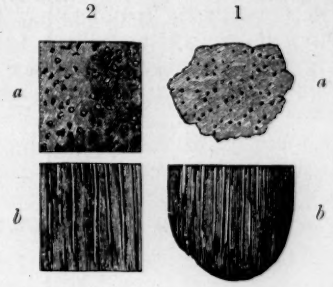


FIG. 1. Palmwood from the Gault, Folkestone.
FIG. 2. Palmwood from Antigua, W. Indies.
a. transverse section. *b*. longitudinal section.

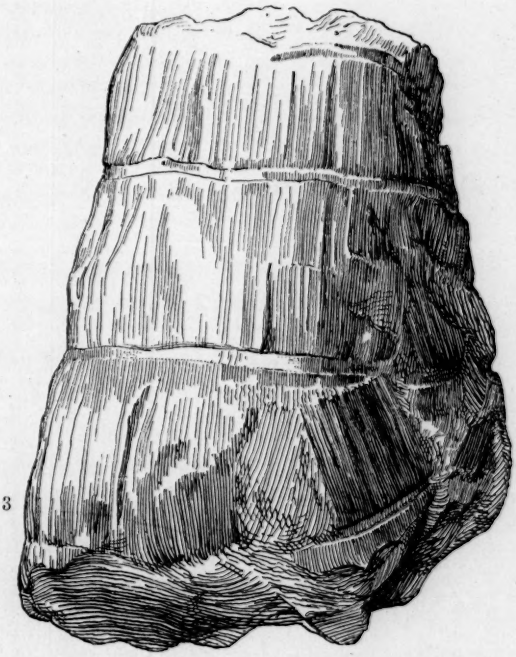


FIG. 3. Stem of the so-called *Calamites Beanii*, Bunbury,[1] from the Inferior Oolite near Scarborough, "one of the Arborescent Gramineæ" (Williamson).

[1] This is the figure referred to on p. 202, GEOL. MAG. May, 1886, as having been lost.—EDIT.

fect specimen with all its organs of reproduction as well as of nutrition, can alone declare with absolute certainty upon its identity or affinity." This mutual dependence requires recognition at the hands of scientific men.

The interesting collection of biographies of eminent palæobotanists is a feature of the work which can be but briefly alluded to here. The names that stand out prominently, and to whom half the literature is credited, are Brongniart, Göppert, Unger, Lesquereux, Heer, Massalongo, Ettingshausen and Saporta; but the biographies are 22 in number, and include the names of our countrymen Witham, Binney, Bunbury, and our eminent and yet living contemporaries Williamson, Dawson, and Carruthers. Of Prof. Williamson, he says: "Of the merits of this work, as of all this author's investigations, it is certainly unnecessary to speak here." Of Dawson: "A geologist rather than a botanist, he has done excellent service, not only in elucidating the important problems of Acadian geology, but also in demonstrating the value and legitimacy of the evidence furnished by vegetable remains." The value of Carruthers' work also receives due acknowledgment, his investigations with regard to fossil fruits having especially "widely expanded this field of knowledge." That Mr. Ward has gracefully acknowledged our indebtedness to these authors no one will dispute, but some may think the praise in other cases has been a little indiscriminate, and that a more critical examination into the quality, as well as the bulk of the work produced, would have rendered greater service to botanists who may require to have recourse to it.

It appears that Walch (1769) was the first to offer anything like a nomenclature of fossil plants, though a few terms such as *Lithoxylon* had for some time previously been in use. *Calamites* is the only one of his names, except *Carpolithes*, that has survived, and this was applied under the misconception that the plants in question were large reeds. Steinhauer (1818) was the first to apply specific names to fossil plants. Schlotheim soon afterwards[1] introduced, among others, two terms which specially interest us, *Palmacites* and *Poacites*, describing respectively 15 and 4 species. Sternberg[2] established the genus *Flabellaria* (I am purposely omitting all reference to Cryptogamic and Gymnospermous genera, in order to concentrate attention on the successive steps by which our knowledge of fossil Angiosperms has been arrived at), and assumed three periods of vegetation, that of Coal-plants, that in which Cycadean types predominated, and that of fucoids and dicotyledons, corresponding of course with the three ages of geology. The system of Martius, which should be interesting, is unfortunately passed over, and we are brought down to Brongniart's first memoir,[3] in which the only genera that interest us are *Exogenites* and *Endogenites*, to include stems whose internal organization is recognizable. Many Angiospermous fruits, leaves and stems had been figured, and more or less described, before this time, for example by Parkinson and Mantell, but none scientifically. In 1828 Brongniart's "Prodrome" ap-

[1] Petrafactenkunde, 1820. [2] Flora der Vorwelt.

[3] Mém. du Musée d'hist. Nat., Paris, 1822, vol. viii. pp. 209-210.

peared, in which he discards his previous artificial classification, and adopts a botanical one. The Gymnospermous were separated from the Angiospermous Phanerogams, the former being considered intermediate between the Cryptogams and true Phanerogams, a proposition which, though placed every year on a firmer basis, is not yet adequately recognized by botanists. Brongniart's system was accepted by almost all writers on the subject, with the notable exception of Lindley and Hutton, who included Cycads and Conifers among Exogens or Dicotyledons, a method still followed, unfortunately for palæontologists, by some of the ablest botanists of the day. They further included *Stigmaria*, *Annularia* and *Asterophyllites* among true Dicotyledons, *Noeggerathia* is placed among the Palms, and *Calamites* is attached to *Juncus*. "One of the most remarkable aberrations of the book," Mr. Ward remarks, "is the pertinacity with which the authors contend for the existence of Cactaceous and Euphorbiaceous plants in the Coal-measures." They in fact utterly ignored the principles laid down by Brongniart and previous writers, and entirely dissented from the theory of progressive development. Cotta's important treatise on fossil wood was followed a year later, in 1833, by Witham's work on the same subject, and by Zenker's[1] description of Cretaceous plants from Blankenburg in the Harz district, the first attempt to treat dicotyledonous fossils systematically. In 1840, Rossmässler proposed[2] to modify Sternberg's method of classifying all fossil dicotyledonous leaves as *Phyllites*, substituting a compound from it and the genus to which the leaves seemed to belong, as *Daphnophyllites*, etc. Thenceforward the plan of naming and describing fossil as if they were real plants, became definitely adopted. The terms *Carpolithes*, *Phyllites*, etc., are still employed where there is absolutely no means of assigning a fossil to any definite group in the vegetable kingdom, but the tendency is far greater towards unwarrantably assimilating leaves with living genera which they resemble, than the employment of any termination, such as "ites," *e.g.* *Pinites*, to suggest that the resemblance may be only apparent.

Passing on to the question of classification, the result of palæobotanical research so far has been to necessitate certain modifications in order to bring the botanical system into accord with the successive appearance of classes of plants in time. The grouping that best meets this requirement is according to Mr. Ward:

- Cryptogams
- Phænogams
  - Gymnosperms
    - Cycadaceæ
    - Coniferæ
    - Gnetaceæ
  - Angiosperms
    - Monocotyledons
    - Dicotyledons
      - Apetalæ
      - Polypetalæ
      - Gamopetalæ

The chief modification introduced is the elevation of the Gymnosperms to the rank of a *class*, while the Monocotyledons and

[1] Beiträge zur Naturgeschichte der Urwelt, Jena, 1833.

[2] Beiträge zur Versteinerungskunde, vol. i. die V. des Braunkohl. aus der Gegend von Altsattel in Böhmen.

Dicotyledons are reduced to *sub-classes*. This is done because the distinction between open and closed ovaries is regarded as a class distinction, and Gymnosperms are not dicotyledonous, but have a variable number of cotyledons ranging from 1 to 15. The conclusion that Gymnosperms form a natural transition from Cryptogams to the higher flowering plants has been arrived at by Sachs and others quite independently of the evidence of fossils.

Valuable statistics have been collected as to the actual numbers of species described, and we find, so far as Angiosperms are concerned, the result to be as follows: For the Carboniferous 8 or 0·5 %, Permian 3 or 0·9%, in the Bunter 4 or 18·2%, Keuper 1 or 2·4%. For the Jurassic we have 1 or 0.8 % in the Rhætic, 5 or 3·7 % in the Lias, 9 or 2·1 % in the Oolite, and inexplicably enough only 1 or 0·8 % in the Wealden. The absence of flowering plants in this formation is one of the mysteries of the Geological Record which Mr. Ward does not elucidate. Vast delta deposits, such as these, composed of most varied kinds of sediments, spread over many and wide areas, in places teeming with plant and other remains of terrestrial life, would appear in every way fitted to have preserved fair representative examples of the vegetation of the period; yet, though monocotyledonous flowering plants must have been far from uncommon then, only a solitary one has been met with. To the close of the Jurassics only monocotyledonous Angiosperms are found, but with the Cretaceous Dicotyledons join them, and the percentage gradually increases until in the Laramie it reaches 37·5 %, a figure only surpassed in the so-called Paleocene. The Eocene would appear the age of Monocotyledons, judged by the 16·8 %, though the Miocene possesses no less than 272 species. Mr. Ward's tables have a statistical value, and enable us to see how far we are advanced; but it is needless to say that even the revision of Mesozoic Angiosperms in the preceding pages of this MAGAZINE has profoundly modified the per-centages of the group in the Jurassic. The supposed Carboniferous and Permian Monocotyledons rest on wholly unsatisfactory material, and Angiosperms cannot at present be traced with any approach to certainty farther back than the Mesozoic period. The value of such a table is again lessened by the possibilities of error in correlating the formations of the two hemispheres. If, for instance, we took the Lower Cretaceous of Europe, we should have a complete absence of Dicotyledons; but if we take the supposed equivalent of the Gault in America, we have "many of our most familiar forms, the poplar, the birch, the beech, the sycamore, and the oak;" "the fig tree, the true laurel, the sassafras, the persimmon, the maple, the walnut, the magnolia, and even the apple and the plum." That the American correlations of the Cretaceous and Eocene deposits of the Western hemisphere with ours, are faulty, becomes more and more apparent, and that many of the Dakotah plants actually belong to the genera quoted is still more open to question. Destructive criticism will, for a long time to come, do more to advance this study than any additions to species, and it is sincerely to be hoped that Mr. Ward or some other competent palæobotanist will devote himself to this side of the problem.

IV.—Notes on Some Hornblende-Bearing Rocks from Inchnadampf.

By J. J. H. Teall, M.A., F.G.S.

In the present communication I propose to describe the petrographical characters of some hornblende-bearing rocks which occur as intrusive sheets and bosses in the limestones and quartzites of the Assynt district. These rocks have been referred to under various names by the different writers on the geology of the district. Prof. Nicol speaks of them as greenstone[1] and trap,[2] and Sir R. Murchison, as syenitic greenstone.[3] Mr. Hudleston[4] indicates their character more definitely by speaking of them as a "kind of diorite." Prof. Bonney, in an appendix to Dr. Callaway's paper "On the Newer Gneissic Rocks of the Northern Highlands," describes the microscopic structure of a specimen from the Traligill Burn near Inchnadampf, and designates the rock a hornblendic porphyrite. Dr. Heddle[5] gives some valuable information as to the distribution of the rocks, and calls attention to the perfection of form exhibited by the hornblende in certain varieties. He gives a figure of the hornblende which shows the forms (110), (010) and (011). With regard to the relations of the rocks to the associated strata he speaks somewhat doubtfully, but evidently inclines to the view that they are intrusive. That this is the case seems proved by the absence of vesicular structure and associated tuffs, and by the fact that although they keep as a rule parallel with the bedding, cases occasionally occur in which they can be seen to move from one horizon to another.

Mr. Hudleston has remarked on the fact that the igneous sheets have been involved in the earth-movements which have folded and faulted the stratified rocks, so that the date of intrusion must lie between the formation of the limestones and the production of the earth-movements which have produced such striking effects in this district.

The specimens on which the following observations are based were mainly collected by myself during the years 1883 and 1884. I am, however, indebted to Prof. Judd for the loan of some which he collected. Those collected by myself were partly obtained from the limestone and partly from the quartzite. Those from the limestone came from the bed which is so well exposed in the Stronchrubie escarpment about three-quarters of a mile south of Inchnadampf, and from the low ground to the north of Inchnadampf, where the rock is exposed in many places. Those from the quartzite came from two localities; one at a point where the 500-feet contour-line crosses the southernmost of two small burns which run into the Calda Burn (Alt á Chalda Mòr) near the most southerly portion of its course, and the other near the base of Beinn an Fhurain, rather more than a mile E.S.E. of Inchnadampf. Prof. Judd's specimens came from the neighbourhood of Inchnadampf, and from a point on the Allt nan

[1] Q.J.G.S. 1856, p. 25. [2] *Ibid.* 1860, p. 97. [3] *Ibid.* 1859, p. 220.
[4] Geol. Mag. 1882, p. 392. [5] Mineralogical Magazine, 1883, p. 138.

Uamh, south of Stronchrubie, at a height of about 700 feet above the sea.

Characters of the Rock-Forming Minerals.

Hornblende.—As this is the mineral which especially characterizes the rocks in question, it will be well to describe it in the first place. It must be remembered, however, that this does not imply that hornblende is always the most abundant mineral. In almost all cases it occurs in well-formed crystals. The larger ones are found in the rock associated with the quartzite. They form short stout prisms, which, however, so far as my observations go, are not terminated by clinodomes (011) as in Dr. Heddle's figure, but by the positive hemi-pyramid ($\bar{1}11$) and the basal plane (001). The forms in the prismatic zone are (110) and (010). The smaller crystals occur usually in elongated prisms, and can only be studied in a satisfactory manner by the use of the microscope. Cross-sections sometimes show the ortho- (100) as well as the clino-pinacoid (010).

The larger crystals may sometimes be completely detached from the rock-mass, and are of such a size that their angles may be measured with a contact goniometer. In all cases the hornblende is green when examined in thin sections. The pleochroism is fairly strong; a = pale-green or yellowish-green, β and γ = deep-green, with only slight differences. One of the most interesting features is the presence, in certain varieties of the rock, of a marked zonal banding, due to a variation in depth of tint in the successive zones. In some crystals a very large number of zones may be detected; in others only two, and in others the crystal appears homogeneous. All these variations may be seen in one and the same rock-section; a fact which seems to show that the crystals have not been simultaneously developed. The zones are in all cases parallel with the external boundaries of the hornblende, except where an original crystal has been obviously fractured and a fragment only is present.

Twinning is frequently present, and the most common type is that in which the orthopinacoid (100) is both twin-plane and face of composition. Sometimes repeated twinning on this plan occurs, so that a crystal is made up of three or four lamellæ.

The alteration of the hornblende is accompanied by the formation of chlorite, epidote, and opacite. In some of the more altered rocks the hornblende is entirely represented by a green chloritic aggregate, in which specks of opacite are abundantly scattered. In these cases the form of the original hornblende is perfectly preserved. In other cases granular epidote is associated with chlorite, and in others epidote occurs to the exclusion of chlorite. In the last-mentioned cases the original form is often lost.

Felspar.—In some of the rocks two generations of felspar may be recognized. The larger porphyritic felspars possess sharply-defined crystalline outline. They occur in moderately thick tables, with conspicuous development of the clinopinacoid (010), and often show a most beautiful zonal banding due to variation in the optical characters

of successive layers. Twinning according to the albite, pericline and probably also the Carlsbad laws occurs; but it is not very constant or uniform. These felspars also evidently possessed inclusions arranged in a more or less zonal manner; but the original nature of these inclusions is difficult to make out in consequence of alteration. It is a noticeable fact that the angles of the inner zones are mostly rounded, although the external faces of the crystals meet in perfectly sharp angles. In some specimens in which the felspars of the first consolidation have been so altered as to have lost to a very great extent their definite optical characters, irregular scales of a vividly polarizing mineral are seen to be scattered through the crystals. These scales often have their long axes arranged in a zonal manner, evidently corresponding with the original structure of the crystal. When examined with a high power, they are seen to possess one strongly-marked cleavage, and to extinguish parallel with this cleavage, so that they may be referred with confidence to a white mica, probably paragonite. The felspars of the ground-mass form together with quartz a microcrystalline aggregate.

In a large number of rocks only one generation of felspars can be detected. When this is the case, the individuals occur as irregular grains, sometimes of considerable size. Mutual interference appears to have prevented the development of definite form. Twinning on the albite plan is sometimes present and sometimes absent. In all cases the felspar-aggregate plays the rôle of ground-mass, and hornblende crystals lie in it, without any regard to the orientation of the individual grains. The coarseness of this aggregate varies between wide limits, sometimes it is so fine as to merit the term microcrystalline, at other times it is so coarse as to remind one of the structure of a medium-grained granite. In some of the thin intrusive sheets the felspars tend to assume the form of small columnar crystals, which give narrow lath-shaped sections, but even in these cases the outlines are not well defined.

Pyroxene.—This mineral is not constantly present. It is pale green when examined on a fractured surface of the rock, but perfectly colourless in thin section. It occurs in somewhat imperfect crystals and also as grains and granular aggregates. The forms of the crystals appear to be those characteristic of the common rock-forming augites. The maximum extinction in the prismatic zone is about 40°. The only cleavages recognized are those of the prism. The mineral has been especially noticed in the rocks which are intrusive in the dolomitic limestone; but it varies very much in quantity even in these, sometimes being absent altogether, and at other times occurring more abundantly than the hornblende. In some of the coarse-grained rocks in which the hornblende attains a considerable size it occurs as inclusions in this mineral. As a good deal has been said about the secondary origin of the rock-forming hornblende, it may be as well to state that no doubt whatever can exist as to the distinctness of the hornblende and the augite in these rocks. Fractured crystals of beautifully-zoned hornblende occur in the porphyritic varieties, and this must be regarded as absolutely conclusive in favour

of the view that this mineral was a product of the consolidation of the original magma.

Apatite.—This mineral occurs in the form of limpid hexagonal crystals, which are usually four or five times longer than broad.

Magnetite.—A small amount of original magnetite occurs in grains and crystals. The opacite (secondary magnetite?) which occurs associated with the chlorite has already been referred to.

Calcite occurs in the form of fine dust thickly scattered through some of the more altered specimens, and also as large crystalline plates in sections which contain the colourless pyroxene. It is possible that the portions of crystalline calcite may be fragments of the limestone caught up by the igneous magma at the time of its intrusion.

Epidote has already been referred to in describing the alteration of the hornblende. It is difficult to say whether all the epidote has been formed in this way.

Quartz is present as a secondary and probably also as a primary constituent in some varieties of the rock.

Mica arises in connection with the alteration of felspar, and it is sometimes found associated with ill-defined aggregates of epidote.

Description of the Rocks.

Macroscopic examination shows that the above minerals occur in very different proportions in the different varieties of the rock. In some the hornblende is very abundant, and these as a rule have a granular aspect; in others it is comparatively scarce. The latter usually contain two generations of felspar and have a marked porphyritic aspect. For the purpose of description we will term them hornblende porphyrites, and the former diorites. It must be remembered, however, that the diorites tend to become porphyritic by the conspicuous development of hornblende; such varieties will be termed porphyritic diorites. The diorites also present us with varieties of texture depending on the coarseness of the grain. In some the constituent minerals may be easily recognized, in others they are so small as to require the microscope for their determination. The latter occur in the thin sheets and at the margins of the intrusive masses.

In the porphyritic diorite near the base of Beinn an Fhurain concretionary patches occur which are more coarsely crystalline and richer in hornblende than the main mass of the rock. In these patches as in the main mass an aggregate of felspar individuals plays the rôle of ground-mass. As a rule the outlines of the inclusions are smooth and curvilinear, but sometimes the large hornblende crystals project for a short distance into the main mass of the rock. It is clear that we have here phenomena similar to those described by Mr. Phillips[1] in the case of the granites. The inclusions in the rock now under consideration agree with those described by Mr. Phillips, (1) in form; (2) in being more basic in composition than the main

[1] "On Concretionary Patches and Fragments of other Rocks contained in Granite," Q.J.G.S. vol. xxxvi. p. 1; and "Additional Note on Certain Inclusions in Granite," Q.J.G.S. vol. xxxviii. p. 216.

mass of the rock; and (3) in the fact that large crystals sometimes project from the inclusion into the ground-mass.

The following analyses will give some idea of the variation in the chemical composition of these rocks.

	I.	II.	III.
SiO_2	63·41	54·09	52·47
Al_2O_3	16·92	15·02	12·15
Fe_2O_3	2·67	4·12	3·47
FeO	2·96	5·15	5·23
CaO	4·32	7·72	9·71
MgO	2·08	7·28	9·94
Na_2O	5·18	1·99	2·81
K_2O	2·36	3·55	2·26
H_2O	·64 Ig.	1·49	1·62
CO_2		—	·54
	100·54	100·39	100·20

I. Hornblende-porphyrite, intrusive in quartzite, base of Beinn an Fhurain.
II. Porphyritic-diorite, base of Beinn an Fhurain.
III. Plagioclase-pyroxene-hornblende rock, near Inchnadampf, intrusive in limestone.

Titanic acid, phosphoric acid, and manganese are present in the above rocks, but have not been determined. They have therefore been weighed with SiO_2, Al_2O_3, and Fe_2O_3. Specimen I. contains two generations of felspar, and is a typical porphyritic rock. Specimen II. contains only one generation of felspars. The hornblende is more abundant than in I., and sometimes occurs in good-sized porphyritic crystals. Specimen III. differs from the others in containing a large amount of colourless pyroxene.

It is seen to be richer in lime and magnesia, but not richer in iron. In all probability the pyroxene is a nearly pure lime-magnesia bisilicate, and one is tempted therefore to ask whether it may not be due to the absorption by the igneous magma of a certain amount of the dolomitic limestone into which the rock has been intruded. The sporadic manner in which the pyroxene occurs is in favour of the view here suggested. As telling somewhat against this view we have to mention the frequent occurrence of a colourless pyroxene in the more basic plagioclase-hornblende rocks, as, for example, in some of Prof. Bonney's hornblende-picrites[1] and the allied rocks of Warwickshire described by Mr. Allport as diorites.[2]

One very interesting feature which a comparison of the different varieties of diorite brings out is the variation in the state of crystallization in the ground-mass. In the compact rocks the individual felspars are minute, and give more or less lath-shaped sections. It is impossible to determine the precise character of the original ground-mass in consequence of alteration, but it evidently approximated to that of the hornblende andesites. In the medium-grained rocks the microstructure of the ground-mass is thoroughly granitic. Here then we see a gradation exactly similar to that described by

[1] On the so-called Diorite of Little Knott, with further remarks on the occurrence of Picrites in Wales, Q. J. G. S. vol. xli. p. 511.
[2] On the Diorite of the Warwickshire Coal-field, Q. J. G. S. vol. xxxv. p. 637.

Messrs. Hague and Iddings[1] as occurring in the diorites and hornblende-andesites of the Washoe district.

A specimen of a fine-grained rock collected by Prof. Judd shows a curious spotted or variolitic structure. The rock is much altered, and it is therefore impossible to ascertain its original character. The spots and the main mass of the rock both contain needle-shaped pseudomorphs after hornblende and a microcrystalline ground-mass. The hornblende-needles are not arranged in any definite manner in relation to the spots; sometimes a needle may be observed with one end in a spot, and the other in the ground-mass of the rock. The external boundaries of the spots are not defined by a sharp line, and where two or more spots coalesce, there is no line of separation between them. Where the spots are best defined, they consist of a central more or less spherical portion, which is rendered nearly opaque by opacite dust, and a marginal portion in which the ground-mass is nearly colourless. The structure appears to be analogous to that of the variolitic diabases.

Comparison of the Rocks with Allied Rocks of other Districts.

The plagioclase-hornblende rocks form a very difficult and somewhat unsatisfactory group. In some, as, for example, the epidiorites of Gümbel, the hornblende is undoubtedly secondary; in others, including the rocks now under consideration, it is certainly original. As the question of the origin of the hornblende is one of the greatest interest in relation to the past history of the rocks themselves and of those portions of the earth's crust of which they form a part, it becomes of importance to separate those in which hornblende is secondary from those in which it is a product of the consolidation of an igneous magma. Mr. Allport[2] has shown that in certain plagioclase-hornblende rocks surrounding the Land's End mass of granite, the hornblende is wholly secondary after augite. Such rocks have therefore no affinities with those now under consideration. The same observer has, however, described certain plagioclase-hornblende rocks (diorites) from Warwickshire,[3] in which the hornblende is mainly original. These rocks have certain points of resemblance with those above referred to. The Warwickshire rocks are, as a rule, much altered; but Mr. Allport was fortunate enough to obtain one specimen from Marston Jabet which was absolutely fresh. It was mainly composed of long prisms of well-formed hornblende set in a crystalline aggregate of plagioclase. This rock, therefore, is closely allied to some of those described in this paper. Another point of resemblance between the Warwickshire rocks and those from Assynt is the occurrence in both of a colourless, or nearly colourless, pyroxene, in association with horn-

[1] On the Development of Crystallization in the Igneous Rocks of Washoe, Nevada, Bull. U. S. Geol Survey, No, 17, 1885.

[2] On the Metamorphic Rocks surrounding the Land's End Mass of Granite. Q. J. G. S. vol. xxxii. p. 407.

[3] Q. J. G. S. vol. xxxv. p. 637.

blende. There are, however, some important points of difference. The original hornblende of the Warwickshire rocks is brown, and where it occurs abundantly is in the form of large ophitic plates containing inclusions of lath-shaped felspar. In the Assynt rocks the hornblende is green, and appears in all cases to have preceded the felspar in the order of consolidation. Again, some of the Warwickshire rocks contain numerous pseudomorphs after olivine, whereas no trace of this mineral has been detected in any of those from Assynt. The ophitic character of the hornblende and the presence of olivine both point to the conclusion that some of the Warwickshire rocks are more basic in composition than any yet found in Assynt. Many of the Anglesea "diorites" bear the closest relation to the corresponding rocks from Warwickshire. They consist of brown hornblende often passing into green, a colourless pyroxene, plagioclase and magnetite or ilmenite. By the coming-in of olivine and the dying-out of the felspar, these rocks shade into Professor Bonney's hornblende-picrite. Mr. Tawney[1] has described similar rocks from the Lleyn peninsula, Caernarvonshire, under the name of hornblende-diabase. An interesting little boss of "diorite" occurs on the right-hand side of the footpath leading from Mount Sorrel to Swithland (Leicestershire), and just outside Brazil Wood.

This boss projects through the soil, and measures only a few yards across. It varies considerably in texture, some parts being composed of a medium-grained granular rock, and others containing large hornblende crystals or plates. Prof. Bonney has described the rock of this knoll as follows: "Under the microscope the latter mineral [hornblende] is seen to occur in irregular grains, plate-like in section, pierced and intersected by the plagioclase [ophitic] with a little iron peroxide (? some of it ilmenite). The hornblende with transmitted light is both brown and green in colour, and much of it and of the felspar is still in good condition. Here and there patches of the pale fibrous actinolitic variety occur, associated with a mineral rather like a fibrous variety of serpentine. These last are certainly secondary products, and much resemble a variety common in the altered Cornish gabbros. Most of the larger hornblende is strongly dichroic. Some of the brown variety resembles biotite. One or two pieces indeed appear from their optical properties to be that mineral. There is a little calcite with characteristic cleavage. The plagioclase often shows brilliant colours and characteristic twinning, with occasional indications of a zonal structure."

My slide of rock from the same locality agrees with Prof. Bonney's description, but contains, in addition to the minerals which he has mentioned, a colourless pyroxene. This brings the rock into the closest relation with some of Mr. Allport's diorites from Warwickshire, with the Anglesea "diorites," and with Mr. Tawney's hornblendic-diabases from the Lleyn peninsula. I would suggest that, for convenience of description, we should use a special locality as a

[1] Woodwardian Laboratory Notes, GEOL. MAG. Decade II. Vol. VII. pp. 212 and 457; also Vol. IX. p. 548.

means of designating rocks of this kind, and as this appears to be the only variety of diorite which is found in the boss at Brazil Wood, it might be termed the Brazil Wood type of diorite. If we do this, we may then state that diorites of the Brazil Wood type occur in Warwickshire associated with Cambrian strata, and also in Anglesea, the Lleyn Peninsula, and the Lake District. It is worthy of note that in no single instance is a diorite of this type known to be associated with Upper Palæozoic or later strata in Britain. I have a specimen of diorite from Glen Tilt (Perthshire) of the same general type, but can say nothing about its mode of occurrence.

The differences between diorites of the Brazil Wood type and those from Inchnadampf described in the present paper have already been referred to. The interesting fact of the close relation of these diorites to Prof. Bonney's hornblende-picrites has also been pointed out.

V.—The Brookwood Deep-Well Section.

By the Rev. A. Irving, B.Sc., B.A., F.G.S.

THIS section, which was completed last year, appears of such value and interest to students of the Tertiary strata of the London Basin, that I have thought it worth while to offer a description of it to the readers of the Geological Magazine. Through the courtesy of Dr. Barton, the Governor of the Asylum, I have had free access to the specimens preserved of the various strata passed through, and very careful use of them has been made in the preparation of the tabulated statement which follows; much of the information having been kindly furnished from the engineers who were employed. The Asylum is situated at Knap Hill, about a mile and a quarter from Brookwood Station on the South-Western Railway, and is on the Upper Bagshot Sands. The mouth of the well is in the valley just below, about 140 feet above O. D., and about the same level as that at which the Middle Bagshot Beds occur in the famous Goldsworthy section, which furnished Prof. Prestwich, some forty years ago, with the clue to the succession of the beds of the Bagshot Formation. It is about a mile and a half distant therefrom. The evidence as to the horizon in the Bagshot Series, at which the well commences, is very clear to those who are familiar with the stratigraphy. The widely-extended pebble-bed at the base of the Upper Bagshot Sands occurs here very near the top of the well, and I saw it exposed again at about the same level in an excavation made by the side of the high road which runs along the western side of the Asylum Estate. The same greenish loamy sand was intermingled with the pebbles in both cases. In the ploughed field a stiff yellow loam, such as so commonly occurs above this pebble-bed in the Bagshot area,[1] crops out in the valley where the well is situated. The 'brown sandy bed' which occurs at the top of the section is probably a portion of this, re-constructed by later drift action, and mingled with more

[1] *Vide* Q.J.G.S. for August, 1885, pp. 493 (No. 2 of the Section).

sandy materials washed down from the sandy strata situated at higher levels on the slopes of the valley.

In attempting to classify the Bagshot Beds I have used the grouping adopted in descriptions recently published of other deep-well sections [1] in the Bagshot District (those namely at Wellington College, Farnborough and Mytchett), and for the reasons there given. A comparison of this section with those brings out a very remarkable continuity in the general characters of the Middle and Lower Bagshot Beds, though there is just that amount of variation in details which we should be led to expect from the conditions under which they appear to have been deposited.[2] I have found it by no means easy to draw a line between the Lower Bagshot Beds and the London Clay, for there is no abrupt transition from one to the other, in the description given below; while a careful study of the actual specimens leaves no alternative that I can see to the recognition of a gradual passage upwards from the London Clay to the characteristic Lower Bagshot Sands. The resemblance of what is seen here to what is seen in the specimens from about the same horizon in the Wellington College well-section is very close indeed; and is in striking contrast with the abrupt transition between the two formations which I have observed in sections already described at Aldershot, Wokingham, and Bracknell, on the marginal portions of the area.

The following points in connection with this section (see p. 355) appear to me worthy of note.

1. The apparent gradual passage from the London Clay into the Lower Bagshot Sands, as contrasted with the abrupt transition observable in the Walton section recently described by Mr. Hudleston,[3] and in those on the marginal portions of the Bagshot area to which I have referred above.

2. The remarkable absence of any considerable development of clays, the *entire absence of all record of pebbles*, and the general predominance of quartz sand stained by carbonaceous matter of vegetable origin are characters which the Lower Bagshot beds of this section possess in common with the Lower Bagshot strata of three deep-well sections, of which I have given a fuller account elsewhere,[4] and to which I have referred above.

3. The specimens of the slightly loamy sands which occur in this section between the depths of 68 and 143 feet bear a striking resemblance to those which occupy about 92 feet of the Lower Bagshots in the section at Wellington College. This resemblance comes out very strongly when the specimens from the two places are directly compared.

4. Of the *pyrites* found in the Bagshot Sands one large heavy specimen (found at the depth of 130 feet) and many smaller ones are preserved. They are quite unweathered, and are probably pyritized wood *in situ*; but with the *cement stones* found in the same beds the case is different. They are very much weathered, their

[1] Q.J.G.S. *loc. cit.*
[2] Cf. Q.J.G.S. *loc. cit.*; also Geol. Mag. Dec. III. Vol. II. p. 25.
[3] Q.J.G.S. April, 1886.
[4] Q.J.G.S. *loc. cit.*

HEIGHT ABOVE O. D. LEVEL ABOUT 140 FEET.

	Thickness of Beds in feet.	Depth in feet.	Strata passed through in the Brookwood Deep Well.
	3	3	Brown sandy bed.
65 feet of Middle Bagshot Beds.	1	4	Gravel (well-rounded pebbles of flint in greenish sand).
	5¼	9¼	Dark sand
	1¾	10¾	'Iron band,' or 'rust'
	¼	11¼	Shaly band
	2¼	13½	Dark sand
	3½	17	'Marly' with sandy veins
			Dark grey and black sand, with traces of pyrites and fragments of clay ironstone highly weathered, with sand-grains adhering to the old surfaces.
	8	25	'Light marl' (quite a pure pipe-clay in the specimens).
	1	26	Brown clay (a very stiff clay slightly laminated).
	4¾	30¾	'Greenish clay.'
	6¼	37½	Dark brown sand.
105½ feet of Lower Bagshot Beds (inclusive of passage beds).	30½	68	Dark sand with *pyrites* and *cement-stones*. [grains).
	10	78	Hard dark (carbonaceous) loamy sand (with some black
	19	97	Lighter grey (carbonaceous) sand (black grains more
	5	102	Darkish grey sand (loamy). [numerous).
	3½	105½	Grey loose sand (with black grains).
	3½	109	Light grey sand.
	11	120	Grey sand (with black grains).
	23½	143½	Dark grey carbonaceous coherent sand, with pyrites.
	6½	150	Hard dark shaly sand and
	1	151	Grey sand. [clay.
	1	152	Dark 'clay.'
			Specimens preserved of a dark grey indurated marl with a very definite fracture.
	2½	154½	Nearly black shale with intervening layers of grey sand, inclosing numerous green and black grains.
	9½	164	Thinly-laminated sandy shale (light grey) with minute black grains and spangles of mica on planes of laminæ.
	5½	169½	Fine clay and sand
	2	171½	Clay
	2	173½	Light grey sand
			The specimens are similar to those of the bed next above, but rather more sandy.
371 feet of London Clay with "basement-bed."	169½	343	London clay.
	½	343½	'Bed of stone.'
	18½	362	London clay.
	5	367	,, ,, with pyrites.
	7½	374½	,, ,,
	½	375	'Bed of stone.'
	25	400	London clay.
	½	400½	'Bed of stone.'
	38	438½	London clay.
	8½	447	,, ,, with pebbles.
	3	450	,, ,,
	10	460	,, ,, (thin sand layers).
	19	479	,, ,, with pebbles.
	29	508	,, ,,
	½	508½	'Bed of stone.'
	9½	518	London clay.
	1	519	,, ,, with pebbles.
	15	534	,, ,,
			The 'beds of stone' may be regarded as septaria for the most part. The only specimens preserved are what appear to be typical of the clay and the stone-beds respectively. The former is a mass of bluish-grey indurated clay, marly enough to have a pretty definite fracture; the latter, "found in the L. Clay," is simply a portion of an ordinary septarian nodule or 'argillaceous limestone.'[1]
89½ feet of Reading beds.	10½	544½	Dark sandy clay (basement-bed of L. clay: no record of
	21½	566	Dark brown mottled clay. [pebbles).
	1	567	'Bed of Stone.'
	6½	573½	Red mottled clay (a very characteristic specimen pre-
	10	583½	Red sandy clay. [served).
	7½	591	Fine sand.
	3	594	Red sandy clay. [olive-green grains).
	8	602	Coarse brown red sand (very ferruginous, with black and
	22	624	Red mottled clay, interbedded with dark grey sand, with traces of pyrites and numerous green grains.
	10	634	Loose grey sand of the same description as in the bed
	250	884	Chalk with flints. [above.
			The specimens of flints preserved from the chalk are of the usual colour of native flint from that formation.

[1] Cf. Etheridge, Manual of Geology and Palæontology, pp. 609, 610.

calcareous material seems to have been entirely dissolved away, and their surfaces are coated with a layer of coarse sand-grains, as if they had rolled about in sand when softened at their surfaces by water. They present a very different appearance to that presented by the specimens found *in situ* in the London Clay. These Bagshot cement-stones may therefore be considered as *derived in all probability from the London Clay itself.*

5. The least thickness we can assign to the London Clay in this section is 371 feet, not including the passage beds at the top. In the paper referred to above[1] I have drawn attention to the greater thickness of the London Clay in these deep-well sections of the more central portions of the main mass of the Bagshot Sands, as compared with the thickness of the London Clay *beneath the Bagshot Sands*, nearer the north and south margins (*e.g.* in the Aldershot Town Well and the Wokingham Well). This difference of course might arise either (1) from attenuation of the London Clay owing to the conditions of original deposition, or (2) to destruction of the upper beds of the London Clay by denudation during the earlier and middle portions of the Bagshot period. The strong evidence we have now in at least two of the more central well-sections of a passage from the London Clay into the Bagshot beds above, goes to show that deposition was continuous in the central portions of the area; while the abrupt transition from the one formation to the other and the frequent erosion of the London Clay surface beneath Bagshot Beds observable in sections on the northern and southern margins point to the obvious conclusion that the London Clay was there at the same time undergoing destruction by denuding agencies. If this be admitted, it is hardly necessary to point the inference that a slight synclinal curvature was given to the London Clay during the earlier portions of the Bagshot period. But this is not all. This Brookwood section is the first, so far as I am aware, to throw some light upon the *horizons* occupied by the 270 feet of London Clay penetrated in the deep well at Wokingham. A reference to the table of strata given by Prof. Rupert Jones, F.R.S., for the Wokingham Well,[1] and comparison of it with the London Clay strata penetrated in this Brookwood section, brings out a remarkable correspondence (in the occurrence of layers of *septaria*, of *pebbles*, and of *pyrites*) between the 273 feet of London Clay at Wokingham and the *lower* 200 feet or rather more of the London Clay in the Brookwood section; while from the *upper* 150 feet or so of the London Clay in the latter section there is no record of such occurrences. So close is the correspondence here cited that there is only a difference of a foot or so in the distance of one of the layers of pebbles in the two sections above the base of the London Clay. These observations harmonize too with the well-known fact that the London Clay becomes more arenaceous, and has a less pronounced marine character in its upper beds, where shown in its full normal development.[2] Of the two alternatives suggested above, we are surely justified, in the light of this new evidence, in preferring the denudation to the original attenuation explanation of the facts, and

[1] Q.J.G.S. *loc. cit.*

[2] Cf. Etheridge, *loc. cit.*

can hardly escape a conclusion favourable to the notion of a certain amount of unconformity between the two formations, along the north and south flanks of the area. The occurrence of sharks' teeth, septaria, and flint pebbles in the London Clay at Aldershot, where I have seen them dug out of the stiff blue London Clay only a few yards below the Bagshot Sands of that section, is also in favour of the assignment of the less than 200 feet of London Clay of that district to the *lower* portions of that formation. In a future paper I shall show that the unconformity inferred from the above evidence can be established from a wider induction.

VI.—The Bois de Fontaine Meteorite, and its Probable Identity with that of Charsonville of 1810.

By James R. Gregory.

A FEW years since I received from a correspondent in Paris several fragments of a meteorite, which my informant stated fell at Bois de Fontaine on the estate of the Marquis de la Touane, near Mung, in the department of Loiret, France, in 1825, but no precise date was given. It was said to be unknown and undescribed. My informant also stated that it was presented to the physician of the Marquis de la Touane, from whom he, my informant, received it in exchange. Of the specimens that I received, two had some of the original crust on them, one a small fragment only, and the other a specimen of 254 grammes, but with only a small amount of crust. I had also five or six other specimens without the crust.

On recently referring to the very detailed accounts of some of the falls of meteorites in the early part of this century in the "Mémoire Historique et Physique sur les Chutes de Pierres," by M. P. M. S. Bigot de Morogue, published at Orleans in 1812, I find a very precise description of the fall at Charsonville, as observed by several eye-witnesses; but what excited my curiosity were the same names of persons and of places mentioned in connection with the Charsonville fall, as with that of the Bois de Fontaine. As the data of the so-called Bois de Fontaine was very meagre, and the year of its supposed fall so widely different, I thought that possibly some error had arisen as regards date. I afterwards compared my specimens of the Charsonville, which I have had in my possession some years, in fact long before the Bois de Fontaine was heard of. The British Museum had indeed a specimen from me of the Charsonville stone at the same time I had mine. I found on careful examination with the Bois de Fontaine that they were identical in texture as well as in colour when fresh broken. To be still more certain, Mr. Thomas Davies, of the British Museum, was obliging enough to allow me to compare my Charsonville specimen with the Museum one, and I also compared a specimen of the Bois de Fontaine with the Charsonville at the same time.

It will be seen that it is possible that the physician named by my informant in connection with the Bois de Fontaine stone may be a descendant of the Dr. Pellieux named in the account of the Charsonville fall in 1810; also that I find Meung in the map of the depart-

ment of Loiret, but not spelt Mung as I had it with the Bois de Fontaine stone, although in M. de Morogue's work it is spelt Meung as in modern maps. In M. de Siemachko's Catalogue, Bois de Fontaine near Beaugency is mentioned, and in M. de Morogue's work it says that Dr. Pellieux resided at Baugenci: this is also probably the same place.

At page 240 of his work Mons. Bigot de Morogue says with regard to the meteorite falls, "The most important which has come to my knowledge is the fall of three stones on the 23rd of November, 1810, in the parish of Charsonville, Canton of Meung, Department of Loiret. At this time I was residing on my estate about six leagues from Charsonville, and a league and a half south of Orleans. Some people attributed it to the explosion of a powder magazine in the direction of Tours; but the true cause did not long remain unknown, for the Baron Pieyre, Prefect of the Department of Loiret, who was as zealous for the progress of science as for the success of his administration, having immediately made inquiry, received a few days afterwards a detailed report from the celebrated physician Dr. Pellieux, residing at Baugenci, a town about two leagues from the place where the stones fell. That report was very interesting, and was accompanied by a fragment of one of the stones, and was read at the Public *Séance* of the Society of Agriculture, Physic, and Medicine of Orleans on November 28, 1810. It was afterwards printed in No. 7 of the report of this learned society, and has been the first public announcement of this event due to a remarkable but nevertheless common phenomenon."

At page 245 of the same work M. Morogue says: "The report of Dr. Pellieux appeared to me to have been written rather hurriedly, and lacked the details which I wished to know; but not being able to go to the place where the stones fell, I wrote to M. de La Touanne, my relative and friend, who was residing at this time on the beautiful estate which bears his name, situate about one league from Charsonville, and begged him to obtain all the details possible on the phenomenon which interested me."

At page 247 he also says: "Monsieur de La Touanne was about one league from the place of the fall, and was walking with his children, when, looking by chance towards the sky in the direction of Charsonville, he heard violent detonations or thunderings, which seemed just over their heads. Forty persons ran from the court of the castle, but they saw nothing. The same evening, however, they heard that some stones had fallen at Charsonville, the fall of which had doubtless caused the noise which had startled them. M. de La Touanne, wishing to verify this fact, went himself the next morning to the place, accompanied by a gamekeeper, a man-servant, and two of his children; arriving at the farm of Villorceau, he was convinced of the truth of the report which he had heard, but no one had either seen the ball of fire or the light. He was told the exact places where the stones had fallen, and he went to examine them himself, and there he picked up some fragments of the stone, one of which he gave me, and he then went himself to visit the holes from which the stones were extracted. He gathered some

details from some of those who had been witnesses of the phenomenon, of which one was a carman, a shepherd, and many others who saw the stones fall close to them. He concluded at last all his researches by saying that on the 23rd of November, 1810, at ten minutes past one P.M. there fell three stones in the parish of Charsonville, Canton of Meung, Department of Loiret. Their fall was accompanied by a series of thunderings which lasted several minutes. The stones fell on a space of ground of about half a league, and their fall was perpendicular. The inhabitants perceived neither light nor globe of fire, either immediately above Charsonville, nor in the neighbourhood. One of the stones fell near Mortelle, and was not found;[1] the two others fell at Villeray and at Moulin-brûlé; of these two, one weighed about 20 lbs. and had been found in a hole just large enough to hold it, and about two feet in depth and one foot in calcareous tuff; this hole was vertical, and the stone was removed about half an hour after it fell, being then hot enough to cause considerable discomfort to those who held it in their hands. The second stone had made a similar hole in the ground, and had penetrated three feet in depth; its weight before being broken was 40 lbs. It was taken up about eighteen hours after its fall. It seems certain that the smaller stone, while still warm, emitted a strong odour of gunpowder, and that it retained it even in the house to which it was taken, until it was quite cold."

At page 250 he continues: "One can see in No. 362 of the 'British Library,' published in January, 1811, an account of the same phenomenon, which was extracted from a letter which Madame de La Touanne had written to her mother, and of which some copies had been by chance circulated through Orleans."

In conclusion I think from this account that it may be taken for a fact that the Charsonville and the Bois de Fontaine meteorites are certainly of the same fall, though there is a probability of the Bois de Fontaine stone being the one that at the time of the fall was not found, and which was described as having fallen at Mortelle by M. de La Touanne. It would, therefore, be interesting to know if those museums and collections possessing specimens of both these stones would carefully compare them in order to ascertain if any similarity exists in their specimens, which might help to prove the identity, and of which myself I have little doubt.

VII.—On the Geological History of the Cornish Serpentinous Rocks.

By J. H. Collins, F.G.S.

(*Continued from* Vol. II. p. 298.)

MY argument that at Porthalla there is a "passage" from hornblende-schist to serpentine; or rather that some beds of a common series have been changed into serpentine, others into hornblende-schist, and others again into a substance of intermediate character, is, I think, much strengthened by the fact that many such "apparent passages" are admitted to exist by all those who have

[1] Query, Was this the stone known as the Bois de Fontaine?—J. R. G.

examined the Lizard Coast with any degree of detail. De la Beche's description of that seen near the Lizard Town is as follows, and it would apply equally well to the others. "The hornblende slate," he says, "supports the great mass of the Lizard serpentine with an apparent passage of the one into the other in many places—*an apparent passage somewhat embarrassing*," that is, from his point of view; from mine it is perfectly natural. He goes on to say: "Whatever the cause of this apparent passage may have been, it is very readily seen at Mullion Cove, at Pradanack Point, at the coast west of Lizard Town, and at several places on the east coast between Landewednack and Kennick Cove, more especially under the Balk . . . . and at the remarkable cavern and open cavity named the Frying-Pan, near Cadgwith."[1] At Kynance some of the laminæ of serpentine are not more than one-tenth of an inch in thickness for considerable distances. It would not be easy to explain how such thin plates of molten intrusive matter could be forced between the laminæ of an already consolidated stratified rock for many feet together. Now, although thin films of remarkably pure serpentinous matter are often found deposited from aqueous solution in thin fissures in certain parts of the Lizard district, yet in such cases as those referred to at Kynance I do not think such an explanation will apply, and I see no alternative but to believe that these thin bands consist of altered material originally stratified and forming part of the same series as the containing rocks.

It seems to me that those who deny the origin of serpentine from certain beds of stratified rock are ready enough to invoke Sir H. De la Beche when his views support theirs. If, on the contrary, they happen to clash with their views, or, which is here the same thing, to support mine, they are very ready to explain away his conclusions.

The popular idea that the Lizard Peninsula is composed almost entirely of serpentine or serpentinous rocks is far indeed from the truth. Considerably less than half the area is so coloured on the Geological Survey Map, and there is good reason to doubt whether the whole of this is actually serpentine. Inland, the excavations are few and far between; on the coasts, many of the cliffs are inaccessible; and it may very well be that large areas of hornblende-schist, mica-schist, gabbro, or even of ordinary clay-slate exist, within the area hitherto regarded as wholly serpentinous, the tendency having been hitherto to mark as serpentine whatever is covered by a soil containing fragments of that rock.

II. The Extra-Lizard Serpentines.

Whatever may have been the origin of the Lizard serpentines, it is certain that serpentinous change in the West of England is not confined to the Lizard District. Serpentinous rocks exist in many other parts of Cornwall and Devon; and probably the total area of what may be called the "Extra-Lizard" serpentines is not less than that of the serpentines of the Lizard Peninsula. Some of these rocks have been described by various writers, and in considerable

[1] Report on Cornwall, etc. See also Memoirs of the Geological Survey.

detail; but the descriptions not being generally known, as are those of the Lizard, I refer to them here a little more in detail.

A large proportion of the Extra-Lizard serpentinous masses seem to have been at one time essentially hornblendic rocks. I do not say *originally* hornblendic, but the production of hornblende has preceded that of serpentine. Some, too, appear to have contained considerable proportions of olivine, but this mineral does not, so far as I am aware, exist in them in an unchanged state.

Some writers draw a notable distinction between *serpentine* rocks and those which are merely *serpentinous*. This is no doubt a convenient distinction in some instances; yet it will be often difficult to define the limits of this distinction, since there is no radical difference. On the one hand, there is no such thing as a rock-mass of pure serpentine; while, on the other hand, all serpentinous rocks, whether approximately pure, porphyritic from the presence of unaltered or only partially altered crystals of foreign matter, or contaminated by streaks and patches of foreign substance, are altered rocks, and the serpentine present, whether much or little, is admittedly an alteration product. To avoid naming such rock-masses serpentine, as that of Duporth for instance, it has been proposed to class them with picrite, but I cannot see that much is gained by this. Some portions of this rock, it is true—from the presence originally of a great many crystals of felspar, now mostly kaolinized—are indeed highly aluminous; but other parts contain very few such crystals, and consequently the alumina sinks to an insignificant amount. But, whatever the amount, the basis of the rock is plainly and distinctly serpentine, and even very pure serpentine; and to call it a picrite, apart from the objections to the use of this term as a rock-name owing to its indefiniteness, seems to me not merely undesirable, but even somewhat misleading, if it be understood to beg the question as to the nature of the original rock. Certainly there is neither olivine nor diallage present now, and it is by no means certain that the rock ever contained either.[1]

I will now proceed to give some brief particulars of the various masses of rock outside the Lizard Peninsula, but within the mining region of Cornwall and West Devon, which exhibit a high degree of serpentinous change.

1. *Veryan*[2] (*Gerrans Bay*).—The serpentinous rock at Veryan is a narrow band of dark green colour, which is associated with well-marked gabbro similar to the rocks which form a great part of the

[1] I do not find picrite mentioned in my edition of Von Cotta. Dana says (p. 258), Picryte from Moravia "consists half of chrysolite (olivine) along with felspar, diallage, hornblende and magnetite." Rutley defines it (Study of Rocks, p. 265) as "blackish-green crystalline rock with a compact black matrix containing porphyritic crystals and grains of olivine. The matrix may consist of hornblende, diallage, or biotite, associated with magnetite and calc-spar. The olivine constitutes nearly half the bulk of the rock." Prof. Bonney regards it as a compound of olivine, a small variable amount of felspar, such as anorthite or labradorite, enstatite or a pyroxenic mineral with biotite.

[2] This district was surveyed by Mr. N. Whitley, of Truro, in 1841, and described in the Report of the Royal Institution of Cornwall. The serpentine was also described by the Rev. Canon Rogers in the Trans. Royal Geol. Soc. of Cornwall, vol. vi. p. 41, 1846.

parish of St. Keverne. It comes in as a wedge between the dark hornblendic "greenstones" of the Nare Head and the Lower Silurian slates and quartzites of the same locality. The excavations upon this band are now mostly filled in, and it is greatly decomposed where it reaches the sea in Gerrans Bay, and appears only as a soft ferruginous mass, so that it is almost impossible to determine whether it is simply an altered bed or occurs as an intrusive mass. For reasons which I need not now specify, I incline to the latter opinion, yet it is worthy of remark, as pointed out by Canon Rogers, that the strike of the band lies in a straight line with that of the serpentine of Porthalla, in the parish of St. Keverne, which is distant some 15 miles to the south-west, and this is at least suggestive of a common origin. However this may be, the serpentines of these two localities are extremely different; the Veryan rock more resembling the ordinary Lizard serpentine than does that of Porthalla. It has no cleavage, but breaks with a splintery fracture like ordinary serpentine. In the mass it is slightly magnetic. Under the microscope, using a 2-inch power, it is seen to consist of a transparent green base, which incloses and surrounds many large much-fractured crystalline masses, not definite crystals, which may be altered olivine. No calcite is visible, but in some places numerous fibres of asbestos may be seen. Throughout the serpentinous ground-mass are sprinkled numerous dark patches of ferruginous matter, as in the serpentine of Coverack. The base of course is not dichroic, nor are the crystalline patches; but these latter are brilliantly coloured by the use of polarized light, especially the asbestos fibres when both polarizer and analyzer are used. The base changes as one Nicol is rotated from pale yellowish green to black. It is possible that this may be altered picrite or some similar rock; but if so, the metamorphosis is very complete, as it contains only one per cent. of alumina. The following are my analyses of this rock:

	1.	2.
Silica	36·55	36·05
Alumina	1·00	·95
Ferric Oxide	8·75	8·00
Ferrous Oxide	2·25	1·00
Chromic Oxide	trace	trace
Lime	trace	trace
Magnesia	32·79	33·79
Alkalies	5·12	4·89
Water (by ignition)	14·59	12·39
	101·05	97·07

I have observed thin layers of serpentinous matter in the joints and fissures of the hornblendic "greenstone" of the Nare Head, where it comes in contact with this serpentine, but I have not sufficiently examined this latter to be able to say whether it exhibits evidence of serpentinous change in itself, or whether these thin films have been merely deposited from water percolating through the rock.

Duporth.—This serpentinous rock has been analyzed and described by Mr. J. A. Phillips[1] and by myself.[2] It seems to form the eastern termination of a dyke of hornblendic greenstone which extends from

[1] Phil. Mag. Feb. 1871. [2] Min. Mag. Nov. 1877.

near the ancient earthwork called Trethullan Castle, in the parish of St. Mewan (near St. Austell), to the sea near Duporth, a distance of over four miles. The typical greenstone in the St. Mewan quarries often contains asbestos and thin layers of serpentine in its joints, and an examination of this intrusive mass in different parts of its course shows that it becomes more coarsely crystalline and porphyritic as it approaches the cliffs, and that the chemical composition is also changed, until finally the hornblendic rock of St. Mewan becomes a serpentine at Duporth.

The less decomposed portions near the sea-level are seen to consist of serpentine of a darker green colour, full of greyish-white spots of a substance resembling kaolin, which on examination appear to be pseudomorphs of hornblende and perhaps felspar, varying from $\frac{1}{20}$ to $\frac{1}{4}$ of an inch in length. The crystals have not quite lost their power of depolarizing polarized light, but the difference between the crystals and the green base in this respect is not extremely great.

The green serpentine base is often somewhat fibrous, the fibres curving round the larger crystals and exhibiting brilliant colours with polarized light; it is sprinkled with very small prisms of scarcely altered felspar. The base and the altered included crystals are both sprinkled pretty thickly with crystals and grains of oxide of iron, and the whole rock is in places stained yellow or brown with per-oxide of iron.

The following analyses show the interesting changes of chemical composition exhibited in this mass in different parts of its course. (*a*) is the mean of three analyses of the rock at St. Mewan made by Mr. Phillips,[1] (*b*) is my own analysis of the rock from the quarry near Gewans, (*c*) my analysis of the rock at Duporth, and (*d*) a recent analysis of the same rock made by Mr. J. Arthur Phillips.[2] (*e*) is a partial analysis of a selected sample which is more free from included crystals and from oxides of iron than ordinarily.

	a.	*b.*	*c.*	*d.*	*e.*
Sp. Gr.	2·27	2·86	2·64	2·86	
Water	·80	·80	8·65	·72 9·29	11·5
Silica	47·57	50·24	37·09	35·74	38·0
Titanic Acid	trace	trace	trace	—	—
Phosphoric Acid	·12	·20	·21	·18	—
Alumina	17·16	19·19	19·90	12·23	4·3
Ferric Oxide Ferrous Oxide	13·04 9·30	15·30	15·54 2·02	4·68 13·84	8·8
Oxide of Manganese	trace	trace	trace	·98	—
Sulphur	trace	trace	—	—	—
Lime	4·11	5·02	trace	trace	—
Magnesia	trace	·93	15·90	22·13	29·2
Potash Soda	2·30 5·45	7·21	trace	trace ·25	— —
	99·85	98·89	99·31	100·04	91·08

[1] Phil. Mag. Feb. 1871.

[2] For this analysis, which was given in the Mineralogical Magazine, *loc. cit.*, I am indebted to Mr. Phillips. He remarks, "I find more magnesia than you do, but

From these analyses it appears that the change is not great at Gewans as compared with St. Mewan, a distance of a mile and a half, and that it consists chiefly in a lessening of the proportions of iron oxides and a slight increase in the silica. Within the next mile, however, a very notable change takes place, the silica being reduced by upwards of 12 per cent., and the alkalies entirely carried off, while the proportion of water increases from less than one to over eight per cent., and the magnesia from less than one to nearly sixteen per cent., or in Mr. Phillips' specimen over 22 per cent. Chemically and mineralogically the rock now consists essentially of something over 30 per cent. of serpentine as a base or ground-mass, containing in crystals and grains nearly 50 per cent. of kaolin, and nearly 20 per cent. of peroxide and magnetic oxide of iron, while in *e* it is a fairly pure serpentine.

I must refer to the paper above mentioned for illustrative drawings of the microscopic structure of the rock. Prof. Bonney considers that from the high proportion of alumina present in this rock, it ought not to be classed with the serpentines; in his Presidential Address to the Geological Society he says of it, "The serpentinous rock of Duporth . . . . appears to be a member of the picrite group. Many of the picrites certainly hang on very closely to the dolerite group, and can be seen to graduate into representatives of it;" but the analyses given above will show that this is an accidental rather than a characteristic component, arising from the distinctly imbedded crystals, and that, in the portions of the rock where these crystals are more sparsely distributed, it approaches in composition an ordinary serpentine rock (which is usually a very different thing to the mineral serpentine).

I have said above why I think this rock should not be classed as picrite. It does indeed seem to have been originally a dolerite, but there is no proof that any considerable proportion of olivine was ever present. The first alteration of the augite seems to have been its conversion into hornblende, and this has subsequently been altered to serpentine.

As to the cause of this remarkable change of a hornblendic into a serpentinous rock, I may remark that the district is one of very extensive disturbance, traversed in all directions by mineral lodes and elvan courses; and it is not more than two miles from the St. Austell granite. I have elsewhere[1] given my reasons in detail for believing that the extensive kaolinization of the felspar of that granite has been produced by mineral solutions acting through fissures from below. I have little doubt that this production of serpentine is due to a similar action, and probably fluoride of magnesia was the principal cause of this alteration, both of the hornblendic base and of the felspathic crystals.

Clicker Tor, near Liskeard.—This remarkable intrusive serpen-

my specimens have undergone more extensive change than yours, as you will see from the fragment which I inclose." He also observes, "My recent analysis of some remarkably fresh rock from the Sanctuaries gave 1·75 per cent. of magnesia."

[1] The Hensbarrow Granite District, 1876.

tinous mass, well known to tourists as well as to geologists, has been fully described by Messrs. Allport[1] and J. A. Phillips.[2]

Mr. Allport regards the serpentinous base as being due to the metamorphism of felspar, and this is no doubt the case to some extent, as at Duporth; however, much of it appears to be due to the alteration of hornblende, itself an alteration product of augite.

Mr. Allport describes it as follows:—

"Under the microscope, a thin slice of the intrusive rock exhibits a variegated mass of pale green serpentine and a nearly colourless substance intimately blended together; imbedded in this matrix there are numerous pseudomorphs after olivine, and irregular plates of unaltered augite, together with minute grains of magnetite scattered here and there through the mass. The pseudomorphs after olivine are of two kinds, consisting either of serpentine or the white substance just mentioned; both are highly characteristic; the crystalline forms are perfectly preserved, and they are traversed by veins representing the original cracks so generally formed in this mineral.

"In one slice the augite is also greatly altered, and it is interesting to compare the two pseudomorphs side by side.

"Although the ground-mass of the rock exhibits a confused amorphous appearance both in ordinary and polarized light, we are fortunately not left in doubt as to the nature of at least one of its original constituents. The augite frequently incloses highly characteristic pseudomorphs after felspar; some are completely inclosed, while others are only partially imbedded in it; the mode of occurrence is, in fact, precisely the same as that observed in the altered gabbro of Costorphine Hill, near Edinburgh, and in several Scotch dolerites described by me on a previous occasion.[3] In many cases the unaltered augite has preserved in the most perfect manner the sharp edges and angles of the felspar prisms; and whenever the latter project from the augite, it may be readily seen that both the inclosed and outlying portions have been converted into precisely the same serpentinous substance as that forming the ground-mass. It should also be noted that, in the case of partially-inclosed prisms, only those sides or ends which have impressed their shape on the augite exhibit a crystalline form, the outstanding portion being quite undistinguishable from the surrounding mass.

"As it would evidently be absurd to suppose that originally there was no felspar save that inclosed in the augite, there can be no doubt that the original felspathic matrix has been completely metamorphosed, and that we have in the Menheniot rock a highly-interesting and instructive example of the conversion of an intrusive olivine-dolerite into a mass of imperfectly-formed serpentine."

The following is an analysis of this rock by Mr. Phillips:—

Silica	36·60
Alumina	17·58
Ferric Oxide...	14·98
Ferrous Oxide	4·52

[1] Quart. Journ. Geol. Soc. 128, Nov. 1876, p. 422. [2] Phil. Mag. 1871.
[3] Quart. Journ. Geol. Soc. vol. xxx. p. 557.

Chromic Oxide	0·14
Carbonate of Lime	2·77
Lime	5·04
Magnesia	5·97
Soda	0·84
Moisture	10·66
	99·10

Polyfant.—The "potstone" of Polyfant near Launceston has long been known as a very infusible and easily wrought rock, one of the few Cornish rocks suitable for elaborate and highly-finished church decoration, and it has been used for such purposes in most of the churches of the neighbourhood,[1] but I am not aware that the rock has been hitherto described from the point of view of the petrologist.

The quarries are very ancient and much filled in, but as far as can be seen they lie in the strike of the associated slates. To the unaided eye the rock appears as a dark greyish-green slightly talcose mass, in some places spotted brown with peroxide of iron. Its structure is somewhat schistose and at the same time brecciated. Whether it be an intrusive mass or an altered volcanic agglomerate is still somewhat uncertain, but I incline to the latter supposition. Under the microscope, and using the 2-inch power, it exhibits a great many colourless crystalline masses, having two cleavages forming oblique angles, which may be altered diallage or enstatite. They are slightly dichroic, but quite dark with crossed prisms. There are also some nebulous nearly circular or hexagonal patches which occasionally have a green spot or a grain of magnetite in the centre. The ground-mass is green—in some parts dichroic; in others not—it is resolvable under the $\frac{1}{4}$-inch power into a fibrous mass of asbestiform material, which polarizes strongly using crossed prisms where thin. A great many black square crystals of magnetite are present—also some patches of brown oxide of iron probably resulting from the decomposition of pyrites.

My analysis of the rock—in duplicate—gives the following as its composition :—

		a.	*b.*
Water given off in dessicator.....	·94		
,, by ignition	12·22	... 13·16	... 13·25
Silica		... 36·90	... 34·75
Alumina		... 11·80	... 12·42
Ferrous Oxide		... 3·56	... 3·50
Ferric Oxide		... 12·00	... 9·10
Lime		... 2·80	... 4·12
Magnesia		... 15·03	... 18·58
Potash		... 3·64	... 3·62
Soda		... trace	... trace
		98·89	99·34

Although there are considerable differences between this composition and that of the Duporth rock, yet if chemical composition alone be taken into account—and *as a whole* there is a good deal of

[1] A shallow basin or crucible of this rock has been recently found in close juxtaposition with a "celt mould" of hard sandy slate at Altarnum, a few miles from the Polyfant quarries. It was probably used for melting the bronze used by the ancient Britons. It is now in the Museum of the Royal Institution of Cornwall at Truro.

analogy between them. But in the Polyfant rock felspar, whether kaolinized or not, seems to be entirely absent, and this forms a notable distinction. Moreover, a great deal of the serpentinous matter certainly does not resemble highly altered olivine; so that, if there be any rock properly to be classed with the picrites in Cornwall, this is it. It must, too, be admitted that the Duporth rock has a good deal of superficial resemblance to it, although it was originally so very different. The Polyfant stone is quite soft—except for the occurrence of occasional hard grains of pyritous or siliceous matter—so that it can be readily cut with a chisel or even with a pocket-knife. Sound fragments have been formed into crucibles and used for melting tin and copper for small castings. It appears to be well adapted for this purpose, although I am unable to say that it has advantage over the ordinary "black-lead" pots.

NOTICES OF MEMOIRS.

I.—Short Notices of Scientific Papers.

1.—Iattagelser öfver qvartära bildningar på Gotland. Af Henrik Munthe. Geol. Föreningens i Stockholm Förhandlingar. No. 100. Bd. viii. H. 2.

2.—Om postglaciala sänkningar af Gotland. Af. G. Lindström. id. No. 102, Bd. viii. H. 4.

THE first of these papers contains many interesting facts respecting the Glacial and Post-Glacial phenomena of the isle of Gotland. Two systems of Glacial striæ have been noted, one, best developed in the north and north-west, has a main direction from N.W. to S.E., and the other, extending over the rest of the island, runs from N.E. to S.W. Raised beaches are traced at various elevations up to 78·5 m. or 259 feet above the sea-level, the highest point on the island. A description is given of a remarkable Ås or Kame near Visby, which rests on Boulder-clay, and is partially covered by it. The erratic boulders are traced from the Aland isles, Angermanland; possibly from the South-west of Finland, and from the bed of the Baltic. Two maps are appended; one showing the direction of the striæ and the contour-lines of the island, and the other of the district round Visby.

In the second paper, Prof. Lindström gives a description of sections lately exposed at Hafdhem in Gotland, in which turf deposits, nearly 50 feet above the sea-level, containing 28 species of existing freshwater mollusca, are overlaid by a marine sand with littoral shells. The author points out certain facts in the configuration and structure of the rock terraces in Gotland which indicate that the island received its present form by denudation, previous to the Glacial Period, and that various changes of level have taken place since that time.

3.—Om Kambriska pyramidalstenar. Af A. G. Nathorst. Ofversigt af Kongl. Vetens.-Akad. Förhandl. 1885. No. 10.

4.—Sur les causes de la production de facettes sur les quartzites

des alluvions pliocènes de la vallée du Rhône, par M. F. Fontannes. Bull. de la Soc. Geol. de France, t. xiv. 1885–6, p. 246.

Dr. Nathorst notices the various opinions held by German and Scandinavian geologists respecting the origin of pebbles with distinctly facetted surfaces, and he points out that, before they had been particularly remarked in Europe, attention had been called to them in New Zealand by Mr. Travers,[1] in 1869, and their facetted surfaces had been rightly attributed to the action of wind-driven sand. The author records the interesting fact that pebbles with facetted surfaces, precisely similar to those from New Zealand and elsewhere, had been lately discovered in the Eophyton sandstone of Lugnås, Sweden.

M. Fontannes brings forward, in the paper cited, several objections against the sufficiency of wind-driven sand to produce the facetted surfaces of the quartzitic pebbles found on the slopes of the Rhone valley, and attributes the phenomena to the current action of water and sand.

5.—On the Minute Structure of Stromatopora and its Allies. By Dr. C. Rominger, Proc. Acad. Nat. Sci. Phil. 1886, pp. 29–56.

This paper is a criticism of the joint essay by Prof. Nicholson and Dr. Murie on the structure of *Stromatopora*, which appeared in the Journal of the Linnæan Society in 1879! It is certainly peculiar to read this review on a paper published six years ago, and one wonders what Dr. Rominger has been doing in the interval. He does not even now seem to be aware that one of the authors of the paper, with which he can see so much to disagree, has in the meantime further studied the subject, and has himself considerably altered his previously-expressed views. It seems somewhat presumptuous on Dr. Rominger's part to propose to substitute some names of his own, which he brought forward in an unpublished paper unluckily rejected by the Smithsonian Institution, for those given by the authors of the paper he criticizes.

6.—Review of the Progress of North American Invertebrate Palæontology for 1885. By J. B. Marcou. American Naturalist Extra, June, 1886, p. 505.

This paper gives a list and a short précis of the various works which have appeared on the subject. The author remarks that there is a distinct increase in the number of articles on palæontology, and that the tendency to publish new species without any illustrations is also diminishing.

7.—A List of the Cretaceous Foraminifera of Keady Hill, County Derry. By Joseph Wright, F.G.S. Proc. Belfast Nat. Field Club Appendix, 1885, p. 327.

Mr. Wright published in 1874 a list of the Cretaceous Microzoa of Ireland obtained from the material in the interior of flints, and the present paper contains a list of 94 species and varieties of foraminifera from the base of the White Chalk at Keady Hill. Twenty-seven of these are additions to the Cretaceous Fauna of

[1] See also a paper by J. D. Enys, "On Sand-Worn Stones from New Zealand." Quart. Journ. Geol. Soc. vol. 34, 1878, p. 86.

Ireland, and three forms, *Gaudryina Jonesiana*, *Bolivina decorata*, and *Marginulina Reussiana*, are new to science. The new forms, as well as some others, are figured in the plate accompanying the memoir.

G. J. H.

REVIEWS.

I.—Monograph of the Earthquakes of Ischia. A Memoir Dealing with the Seismic Disturbances in that Island from Remotest Times, with Special Observations on those of 1881 and 1883. By H. J. Johnston-Lavis, M.D., F.G.S., etc., and Some Calculations by Rev. Prof. Samuel Haughton, M.D., F.R.S. 4to. pp. 112. With numerous Plates and Photographs. (F. Furchheim, Naples; Dulau & Co., London, 1885.)

IN this work Dr. Johnston-Lavis has essayed to do for the recent earthquakes of Ischia that which was so well accomplished for the great Neapolitan earthquake of 1857 by the late Mr. Robert Mallet. In the mathematical portion of the work he has been fortunate in securing the co-operation of Dr. Haughton, who supplied Mr. Mallet with the necessary equations for his work.

The excellent way in which Dr. Johnston-Lavis made use of his opportunities as a resident in the neighbourhood, after the earthquakes of 1881 and 1883, is very well known; and the columns of *Nature* and various newspapers were supplied with detailed accounts of catastrophes from his pen, many of which contain observations of considerable scientific value. But in the present work, he has treated the whole subject in a systematic and comprehensive manner, and has succeeded in producing a book which, like that of Mallet, is of great value both to seismologists and geologists.

After a short introductory chapter, the author devotes six pages to a *résumé* of what is known concerning the geology of Ischia, based on the researches of Scacchi, Fonseca, Vom Rath, Fuchs, and other geologists. Chapters III. and IV. are chiefly historical; the former dealing with the earthquakes and eruptions which have occurred in the island from the earliest historical times down to the present day; while the latter contains a translation of Covelli's interesting account of the Ischian earthquake of February 2nd, 1828. Chapters V. and VI. are occupied with the details of the author's own observations on the effect of the earthquakes of March 4th, 1881, and of July 28th, 1883, respectively. The destructive effects of these great earthquakes are made strikingly apparent to every one, and especially to those who have visited the island, by the series of admirable photographs, taken for the most part by the author himself, and reproduced for the purpose of this work in Turin.

The next three chapters of the book are devoted to a discussion of the nature of the earthquake waves, and of the paths which they followed, and to a determination of the positions of the seismic vertical, the epicentra, and the isoseismals of the two earthquakes; while,

from the observations on angles of emergence at various points, conclusions are deduced as to the form of the "focal cavity" and its mean depth from the surface. It is admitted that the data obtained by those observations are too few and imperfect to base absolutely reliable conclusions upon; but the careful plotting upon maps and sections of those measurements which seem most worthy of confidence, points to the conclusion that the centre of the disturbance was the same in both cases, and must be sought on a line less than one mile in length, running nearly north and south beneath Casanenella from near Lacco towards Fontana. The mean depth of the focus was calculated for the earthquake of 1881 as 518·25 metres from the sea-level, and that of 1883 as 528 metres. The author suggests that the seat of disturbance is a vertical fissure, filled with igneous matter, which is gradually extending itself upwards towards the surface.

In a chapter on the phenomena connected with the earthquakes, the author points out that the Ischian earthquakes were accompanied by muffled rumblings, which near the centre were simultaneous with the shock, but which further away from the centre preceded the shock. Dr. Johnson-Lavis' careful investigation of the reported changes in thermal and other springs in the island before the shock led him to the conclusion that these reports were for the most part unworthy of credence; but in the case of a well near Forio, what seems to be satisfactory evidence is adduced in support of the conclusion that shortly before and after the earthquake sudden changes in the qualities of the water took place; and Prof. Palmieri suggests that the well might be in communication with a fumarole, which from time to time exhibited increased activity. Landslips affecting the soft tufaceous masses which cover so large a part of the island are also shown to be a frequent accompaniment of earthquake-shocks, though they also sometimes occur quite independently of seismic disturbances.

In his two final chapters, and in an appendix, the author indulges in some interesting speculations concerning the cause of the earthquakes of Ischia, and he ventures on some suggestions as to the best methods by which their destructive effects may be guarded against or even prevented. If, as he thinks, a fissure on the side of the old volcano of Eporneo is being extended upwards, till at last the disturbances will culminate in a volcanic outburst, producing another parasitical cone on the old volcano, he suggests that a deep bore-hole might serve as a safety-valve to prevent the destructive accumulation of steam. More practical, perhaps, is the suggestion that careful seismic observations with suitable instruments might result in obtaining useful warnings, as well as more exact knowledge of the phenomena. And lastly he points out that not a little may be done, during the rebuilding of the towns, in the selection of sites, the arrangement of the positions and forms of houses, and in the choosing of the materials and designs of their construction, to ward off the terrible dangers which seem to beset them.

In concluding this notice of a very interesting work, we must

heartily congratulate its author upon the energy and zeal with which he has performed his self-appointed task, no less than on the character and appearance of the volume in which he has recorded his results.

II.—Earthquakes and other Earth-Movements. By Prof. John Milne, F.G.S. With 38 Figures. Vol. LVI. of the International Scientific Series. (Kegan Paul, Trench & Co.)

SINCE Mallet's "First Principles of Observational Seismology," better known as "A Report on the Neapolitan Earthquake of 1857," no book has appeared on this subject comparable in importance to the present volume. This seems indeed to mark a new epoch in the progress of the science, as that book certainly marked a former epoch, which should probably be reckoned the first. A contrast may be drawn between the two. The first is mainly observational, and its observations are made on single great earthquakes; its names are Mallet and Hopkins; its region of research is Italy; and its conception of an earthquake is one or more shocks. The new epoch is experimental as well as observational; and its observations are made on all, even the minutest tremors; Ewing, Gray, Milne, are its names, its classic region is Japan; and it conceives an earthquake as a train of vibrations. Its great advance is due to the introduction of an instrument of exact research, the seismograph properly so called, a seismometer with recording apparatus. All previous means, the author remarks, ought to be classed not as seismometers capable of measuring a disturbance, but as bare seismoscopes indicating only that a disturbance has taken place.

Our volume presents a full view of the present state of knowledge on this obscure and difficult subject. If any person wonder that so complete a treatise can issue from so remote a region, let him remember that from that region come all the latest additions to our information. Much credit is due to Mr. T. Gray for his revision of the proofs. The correctness shows the pains that must have been bestowed. The only serious error we have noticed is in the equations, etc., of p. 211. Here certainly either explanation or correction is needed. Ought not the index of the second power to be affixed to each letter in these equations?

No branch of the study is neglected: all receive attention. Even practical aspects, so often despised by men who suppose themselves scientific, here have a full share of notice. The 'general conclusions' at the end of Chapter VII. give valuable advice to those who have to build a house in a region exposed to such dangers. There is even a suggestion for the use of Earthquake lamps to extinguish themselves in the act of being overthrown. The 'Earthquake coats,' described as having pockets ready filled with provisions as preparation at a moment's notice for spending a night in the air, relieve with a little amusement more serious recommendations. Undoubtedly the most important notes of advice are No. 8: 'Follow one of the two systems for constructing an earthquake-proof building,' and No. 1: 'In choosing a site, find out the localities which are least disturbed.'

The chapters on the 'Distribution in Time' of earthquakes contain much information and some valuable tables. Extremely interesting is an attempt to exhibit graphically the variations of seismic energy for a particular district, that of Kioto, during twelve centuries. It is curious to find not a continuous decrease but a general diminution interrupted by a temporary increase four centuries back. Not much faith, however, can be placed in any conclusions based on mere records of remarkable shocks. We find surely the temperature of a day easier to estimate than the intensity of a shock. Yet how uncertain are we still as to any real alterations in English climate during a like succession of ages.

Far better founded are the discussions as to the relations of earthquake frequency, intensity, or time of occurrence, with seasons, tides, planets, or barometer. Even here, however, negative answers are disappointingly prevalent, and the solitary result to emerge is that their number is greater in winter.

More valuable and far more trustworthy conclusions are obtained under the heading, 'Distribution in Space.' The author's somewhat novel sport of 'Earthquake hunting' (Chap. X.) has already brought to light several facts of the first rank in importance. Such are, the existence of groups with more or less definite boundaries and separate centres of radiation (see p. 191); the significant coincidence of much-shaken regions with lines where continents dip steeply into oceans; and the action of mountain ranges in barring the progress of a shock. More information on this last now celebrated observation is very much to be desired. Some mountain countries (as Switzerland) are often shaken. Do these shocks originate in the mountains, and if so do they extend into the plains? or does each region keep its products to itself? Is there Free Trade in earthquakes there, or Protection? If delicate instruments like Professor Milne's were judiciously placed and regularly observed, we think it probable that much information might be obtained on points of this nature.

Descriptions of these beautiful instruments form a very interesting portion of the book. The account is, however, brief. It enables the reader to see the action of the machines, but does not go very deeply into either fundamental principles, or practical difficulties. For these a student must refer to the various original memoirs. The principle which underlies all these machines alike is that the surface of the earth moves, and that to obtain a true record of its motion, something must be provided which remains unaffected and does not move with the earth. A freely suspended pendulum fails because a motion of its point of attachment soon creates motions of the bob. A slab on rolling spheres fails because impulses to the slab by friction from the balls cannot be avoided. And whereas a beginner would expect a moving point to write records on a plate, the reader will learn that the writing point is arranged to be motionless, while it is the recording plate which moves with the earth. The difficulty of recording vertical motions by any device is so great that one almost disbelieves any measure of success can be obtained. Ingenious means for overcoming these difficulties are described,

and students desirous of learning more may consult a paper in vol. xxxix. of the Quarterly Journal of the Geological Society; and the Transactions of the Seismological Society of Japan. Not the least important application of those beautiful instruments has been the observation of artificial earthquakes. Much curious and useful information has thus been obtained. The effects of canals and even ditches in arresting surface vibrations, though to some extent previously known, are here more completely established. A result of the highest scientific importance that seems looming in the possible future is a true measure of the intensity at origin of a disturbance, as is hinted at on page 62. One drawback to the value of these experiments is that they are made solely with disturbances produced by percussion or explosion, while we can hardly doubt that some earthquakes at least, and probably very many, are due to causes which have no resemblance to a blow.

Interesting purely theoretical discussions will be found in various parts of the book. The diagram in Chap. VII. illustrating reflection and interference is clear and instructive, but readers should remember that the energy of a reflected shock is probably greatly diminished from the energy of incidence. The problem of deducing the origin of an earthquake from observations of its time of occurrence at several distinct points receives elegant treatment in Chapter X. All methods described are vitiated theoretically by changes in velocity of propagation (which Prof. Milne himself has shown to exist), and practically, in such cases as our own Colchester Earthquake, by the inexactness of most records of time. When these last can be trusted, it is probable that the theoretical methods will approximate to the true origin, if there be one, with sufficient accuracy for any practical purpose.

A well-known effect, often observed and often commented on, the rotation produced in many objects by the earthquake, is discussed in the chapter on 'Determination of Origins.' Preference is given to an ingenious explanation credited to Mr. Gray. We cannot, however, ourselves see that this is a very essential advance on the explanation given by Mallet. Their common principle is that a resultant impulse which does not pass through the centre of gravity will create in the body rotation, and the point of the new suggestion appears to be that in bodies on rectangular bases, this impulse must in general come from one angle. The explanation is not applicable for circular bases. Both seem insufficient in view of Meldola and White's observation ("East Anglian Earthquake of 1884," p. 206), that chimneys were in general rotated all in the same direction; with which agrees Prof. Milne's own remark on the stones of the Yokohama cemetery. After all, what object is there in trying to dispense with 'vorticose motion'? As we are dealing not with water, but with earth, the only meaning of the phrase is that a vibratory motion is propagated in a direction transverse to the direction of vibration; the transmission, in brief, of a wave of shearing strain. All instruments at present in use only record the motions of a single point, and none of them are able to distinguish between normal vibrations and transversal such as these.

In Chap. III. a lucid but too brief exposition is given of the consequences from snap after tension, slip after shear, and shock after explosion of steam. The question of Cause is again referred to in Chap. XVII., and other notices occur. The accounts of Earth Tremors and Earth Pulsations refer to subjects which ought, one would hope, to lead hereafter towards much completer insight into earth-crust state, but at present they only raise, without gratifying our hopes. The possible connection of these with secular oscillations of land and sea is necessarily dismissed with no more than a reference to the possibility. Materials do not exist for anything fuller.

Readers may from time to time be conscious that what they are reading is somewhat familiar, that they have met with the account or seen the figure in some not very ancient paper, number, or volume. Ample defence, were defence necessary, would be that such a conspectus of knowledge must, from the nature of the case, be largely a compilation. But there is another reason. It was said once: 'None but himself can be his parallel.' Prof. Milne might almost say that none but himself could be his authority. Those most interesting notes on the results of Japanese observations that have from time to time appeared in "Nature," are to a large extent abstracts of papers from the Seismological Society's Journal. Prof. Milne could find scarce any store worth pillaging except the productions of his own creation. E. H. (Camb.).

III.—Contributions to American Palæontology. Vol. i. No. 1. Published by E. O. Ulrich, Cincinnati, 1886. 8vo. pp. 35, pls. 1—3.

ACCORDING to Mr. Ulrich's experience, the learned societies of America are inadequate to the needs of the Palæontologist, since if they accept papers, they are unable or unwilling to furnish the necessary illustrations, and he therefore intends to make himself independent by bringing out, from time to time, a series of what are styled "private publications," of which the present number is the first.

It contains descriptions of "New Silurian and Devonian Fossils," for the most part Bryozoa. A fresh classification, to replace one brought forward by the author in 1882, is proposed for the families Fenestellidæ and Acanthocladidæ. In the former, three new genera are introduced, but they are left without names; there is no description of any type species; and their essential characters appear to be extremely slight.

Descriptions and figures are given of a number of new species belonging to the genera *Fenestella*, *Semicoscinium*, *Unitrypa*, *Polypora*, *Fistulipora* and *Eridopora* in addition to two new genera, *Buscopora* and *Lichenotrypa*.

The author bases a new genus of Brachiopoda, named *Schizobolus*, on the internal characters of *Discina truncata*, Hall. The generic affinities are stated to "appear to lie between the Obolidæ on the one side and the Discinidæ on the other; the dorsal valve is not unlike that of *Discina*, whilst the whole shell resembles Discinisca,

Dall." The author describes the specific characters in detail, but fails to point out those which should mark the proposed genus from its nearest allies.

A new species of *Rhynchonella* is founded on specimens showing casts of the interior, and a new species of *Gypidia* is described. Several new species of *Platyceras*, a new genus of corals, *Bucanophyllum*, and new species of *Strombodes* and *Labechia* are introduced and figured. Finally a new genus of Foraminifera named *Moellerina* is based on some minute orbicular bodies with spiral ridges on the outer surface. It seems to have escaped the notice of the author that these bodies have been already described and figured by Professor Dawson, as *Saccammina* (*Calcisphæra*) *Eriana*, and that they were previously mentioned by Prof. Meek as probably the fruits of *Chara*.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 23, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:

1. "On some Perched Blocks and associated Phenomena." By Prof. T. McKenny Hughes, M.A., F.G.S.

The author described certain groups of boulders which occurred on pedestals of limestone rising from 3 to 18 inches above the level of the surrounding rock. The surfaces of these pedestals were striated in the direction of the main ice-flow of the district, while the surrounding lower rock in no case bore traces of glaciation, but showed what is known as a weathered surface.

He inferred that the pedestals were portions of the rock protected by the overhanging boulder from the down-pouring rain, which had removed the surrounding exposed parts of the surface. When the pedestals attained a certain height relatively to the surrounding rock, the rain would beat in under the boulder, and thus there was a natural limit to their possible height.

He referred to the action of vegetation in assisting the decomposition of the limestone, and considered that there were so many causes of different rates of waste and so many sources of error, that he distrusted any numerical estimate of the time during which the surrounding limestone had been exposed to denudation.

Considering the mode of transport of the boulders, he thought that they could not have been carried by marine currents and coast-ice, as they had all travelled, in the direction of the furrows on the rock below them, from the parent rock on the north. Moreover, marine currents would have destroyed the glaciation of the rock and filled the hollows with débris.

Furthermore, the boulders and striæ are found in the same district at such very different levels and in such positions as to preclude the possibility of their being due to icebergs.

Nor could the boulders represent the remainder of a mass of drift which had been removed by denudation, for the following reasons:—

1. They were all composed of one rock, and that invariably a rock to be found in place close by.

2. Any denudation which could have removed the clay and smaller stones of the drift would have obliterated the traces of glaciation on the surface of the rock.

3. The boulder which had protected the fine glacial markings below it from the action of the rains would certainly in some cases have preserved a portion of the stiff Boulder-clay.

4. The margin of the Boulder-clay along the flanks of Ingleborough was generally marked by lines of swallow-holes, into which the water ran off the Boulder-clay; and when the impervious beds overlying the limestone had been cut back by denudation, a number of lines of swallow-holes marked the successive stages in the process; but there was not such evidence of the former extension of the drift up to the Norber boulders.

5. The boulders themselves were not rounded and glaciated in the same way as the masses of the same rock in the drift, but resembled the pieces now seen broken out by weathering along the outcrop of the rock close by.

Having thus shown the improbability of these boulders having been let down out of a mass of drift the finer part of which had been removed by denudation, or of their having been masses floated to their present position on shore-ice, he offered an explanation of their peculiar position, which he thought was not inconsistent with the view that they belong to some part of the age of land-ice.

That they were to be referred to some exceptional local circumstances seemed clear from the rarity of such glaciated pedestals, while boulders and other traces of glaciation were universal over that part of the country. He therefore pointed out in explanation, that they occurred always where there was a great obstacle in the path of the ice:—at Cunswick the mass of Kendal Fell curving round at the south and across the path of the ice; at Farleton the great limestone escarpment rising abruptly from Crooklands; at Norber the constriction of the Crummack valley near Wharfe and the great mass of Austwich grit running obliquely across its mouth. In all these cases the ice had to force its way up hill; and there would be a time when it would just surmount the obstacle after a season of greater snowfall, and fall back after warm seasons, until it fell back altogether from that part. During the season of recession, boulders would be detached below the ice-foot; during the seasons of advance they would be pushed forward; and in those exceptional localities of isolated hills from which the drainage from higher ground was cut off, the boulders were left on a clean furrowed surface of limestone, which was then acted upon by rain-water and the vegetation, except where protected by the boulders.

2. "On some Derived Fragments in the Longmynd and Newer Archæan Rocks of Shropshire." By Dr. Charles Callaway, F.G.S.

Further evidence was added to that given in the author's previous paper (Q.J.G.S. 1879, p. 661), to show that the Longmynd rocks of Shropshire were chiefly composed of materials derived from the

Uriconian series, and that the Uriconian series itself (Newer Archæan) was partly formed from the waste of pre-existing rocks. This evidence consisted of (1) the presence, throughout the greatly developed Longmynd conglomerates and grits, of purple rhyolite fragments, recognized by microscopical characters as identical with the Uriconian rhyolites of the Wrekin, and the occurrence of grains, probably derived from the same rhyolites, in the typical green slates of the Longmynd; and (2) the existence of conglomerate beds containing rounded fragments of granitoid rock in the core of the Wrekin itself, whilst the Uriconian beds of other localities, and especially those of Charlton Hill, contained waterworn pebbles, chiefly metamorphic. These pebbles appeared to have been derived from metamorphic rocks of three distinct types. The views put forward were founded on microscopical evidence, of which some details were given in the paper, and were supported by the views of Professor Bonney, who had furnished notes on the microscopical characters of the rocks.

3. "Notes on the Relations of the Lincolnshire Carstone." By A. Strahan, Esq., M.A., F.G.S.

The Lincolnshire Carstone has hitherto been supposed to be correlative with the upper part of the Speeton series, and to be quite unconformably overlain by the Red Chalk (Quart. Journ. Geol. Soc. vol. xxvi. p. 326–347). But the overlap of the Carstone by the Red Chalk, which seemed to favour this view, is due to the northerly attenuation, which is shared by nearly all the Secondary rocks of Lincolnshire. Moreover, the Carstone rests on different members of the Tealby group, and presents a strong contrast to them in lithological character, and in being, except for the derived fauna, entirely unfossiliferous. It is composed of such materials as would result from the "washing" of the Tealby beds.

In general it is a reddish-brown grit, made up of small quartz-grains, flakes and spherical grains of iron-oxide, with rolled phosphatic nodules. Towards the south, where it is thick, the nodules are small and sporadic. Northwards, as the Carstone loses in thickness, they increase in size and abundance, so as to form a "coprolite-bed," and have yielded specimens of *Ammonites speetonensis*, *A. plicomphalus*, *Lucina*, etc. When the Carstone finally thins out, the conglomerate character invades the Red Chalk, similar nodules being then found in this rock.

The presence of these nodules, with Neocomian species, taken in connexion with the character of the materials of the Carstone, points to considerable erosion of the Tealby beds. On the other hand, there is a passage from the Carstone up into the Red Chalk. It would seem, then, that the Carstone should be regarded as a "basement-bed" of the Upper Cretaceous rocks.

The Lincolnshire Carstone is probably equivalent to the whole of the Hunstanton Neocomian, the impersistent clay of the latter being a very improbable representative of the Tealby Clay. It therefore follows that the whole Speeton series is absent in Norfolk, and also in Bedfordshire. The unconformity at the base of the Carstone

becomes greater southwards, and the nodules have been derived from older rocks. Similarly north of Lincolnshire, where the Speeton series is overlapped, the nodules in the Red Chalk, marking the horizon of the Carstone, have been derived from Oolitic rocks.

In the South of England it would seem that equivalents of the Speeton series reappear. The Atherfield clay contains an indigenous Upper Speeton fauna, while a pebble-bed near the base of the Folkestone beds is described by Mr. Meyer as containing derived Oolitic pebbles, and being probably the representative of the Upware deposit, and presumably, therefore, also of the Lincolnshire Carstone.

4. "The Geology of Cape-Breton Island, Nova Scotia." By Edwin Gilpin, Esq., Jun., A.M., F.R.S.C., Inspector H.M.'s Mines.

After referring to previously published descriptions of Cape Breton geology, the author stated that the various formations found in the island had been thus classified by the officers of the Geological Survey:—

Pre-Cambrian (Laurentian) including		The Felsite series. The Crystalline Limestone series.
Lower Silurian, Devonian. Carboniferous, including		Lower Coal-formation. Gypsiferous series. Limestones, etc. Millstone-Grit. Middle Coal-formation.

He then proceeded to give an account of each system and its subdivisions in order, commencing with the most ancient and adding a few detailed sections of the rocks belonging to some of the principal series. He described the distribution and relations of the several divisions.

The paper concluded with a few notes on the superficial geology of the island. There is a general absence of moraines and of the fossiliferous Post-Pliocene marine clays of the Lower St. Lawrence. The older beds are generally exposed, but deeper soils and deposits with erratic boulders are found overlying the Carboniferous beds. Marks of recent ice-action are found on the shores of some of the lakes, and are due to the ice being driven by the wind.

5. "On the Decapod Crustaceans of the Oxford Clay." By James Carter, Esq., F.G.S., etc.

The author commented on the paucity of these fossils as indicated in British lists, only three or four species having hitherto been recorded.

The discovery of considerable numbers of Decapod Crustaceans in the Oxford Clay of St. Ives has enabled the author to increase the list materially. Many have been collected by Mr. George, of Northampton. These fossils occur in the clay immediately beneath the St. Ives rock, and therefore presumably in the uppermost zone of the Oxford Clay. Many of the specimens are more or less mutilated, but some fifteen or sixteen distinct species have been made out. None of these have been recorded as British except *Eryma Babeaui*, mentioned by Mr. Etheridge as having been found in

the Kimmeridge Clay. Seven species are identified as foreign forms, and seven are new to science. They are distributed as follows:—

Eryon	1	species.
Eryma	5 or 6	,,
Glyphea	2	,,
Magila	2 or 3	,,
Mecochirus	2	,,
Goniochorus	1	,,
Undetermined	3	,,

Nearly all the forms belong to the type of the Macrura, the Brachyura being doubtfully, if at all, represented.

6. "Some Well-sections in Middlesex." By W. Whitaker, Esq., B.A. Lond., F.G.S.

Accounts of many well-sections and borings having been received since the publication of vol. iv. of the Geol. Survey Memoirs, the author now gave more or less detailed descriptions of fifty-six of these, all in the Metropolitan county, and all either unfinished or, in a few cases, with further information as to published sections. The depths range from 59 to 700 feet, more than half being 300 feet or more deep. Nearly all pass through the Tertiary beds into the Chalk, and most have been carried some way into the latter. Papers descriptive of like sections in Essex, Herts, and Surrey have been sent to Societies in these counties.

7. "On some Cupriferous Shales in the Province of Houpeh, China." By H. M. Becher, Esq., F.G.S.

This communication contained some geological observations made during a visit to a locality on the Yangtse river, near I-chang, about 1000 miles from the sea, for the purpose of examining a spot whence copper-ore (impure oxide with some carbonate and sulphide) had been procured.

The principal formations in the neighbourhood of I-chang were said to be Palæozoic (probably Carboniferous) limestones of great thickness, overlain by brecciated calcareous conglomerate and reddish sandstones, which form low hills in the immediate vicinity of the city. About fifty miles further west the limestones pass under a great shale-series with beds of coal, the relations of which to the sandstones are not clearly ascertained.

The copper-ore examined by the writer came from the shales, which contained films and specks of malachite and chrysocolla, and in places a siliceous band containing cuprite, besides the oxydized minerals, was interstratified in the beds. Occasionally larger masses of pure copper-ore are found imbedded in the strata. The ground had not been sufficiently explored for the value of the deposits to be ascertained.

8. "The Cascade Anthracitic Coal-fields of the Rocky Mountains, Canada." By W. Hamilton Merritt, Esq., F.G.S.

The coal-field named occurs in the most eastern valley of the Rocky Mountains, that of the Bow river, and, like other coal-fields of the country, consists of Cretaceous rocks, which lie in a synclinal trough at an elevation of about 4300 feet above the sea. The underlying beds, of Lower Carboniferous or, possibly, Devonian age, rise into ranges 3000 feet higher.

Further to the eastward the Jurassic and Cretaceous coal contains a large percentage of hygroscopic water and volatile combustible matter, and has the mineral composition of lignite. The average composition is :—

Fixed carbon	42 per cent.
Volatile combustible matter...	34 ,,
Hygroscopic water...	16 ,,
Ash...	8 ,,
	—100

As the mountains are approached, the amount of hygroscopic water is found to diminish by about one per cent. for every ten miles, and fifteen miles from the range the percentage is about five. In the foot-hills the lignites pass into a true coal, with 1·63 to 6·12 per cent. of hygroscopic water, and 50 to 63 per cent. of fixed carbon. In the Cascade-river Coal-field the average character of the coal is that of a semianthracite, with the following composition :—

Fixed carbon	80·93 per cent.
Volatile combustible matter	10·79 ,,
Hygroscopic water	·71 ,,
Ash	7·57 ,,
	100·00

The coal-seams have been subjected to great pressure, and the change in the quality of the coal appears to be due to metamorphic influence.

9. "On a new Emydine Chelonian from the Pliocene of India." By R. Lydekker, Esq., B.A., F.G.S.

The author described the shell of an Emydine Tortoise from the Siwaliks of Perim Island, Gulf of Cambay, which he regarded as decidedly distinct from any of the previously-described Siwalik species, and proposed to refer to the genus *Clemmys*, with the name of *C. Watsoni*, in compliment to the donor of the specimen.

10. "On certain Eocene Formations of Western Servia." By Dr. A. B. Griffiths, F.R.S.E., F.C.S. Communicated by the President.

A great thickness of paper-shales containing paraffin occurs near the river Golabara; these extend over 30 square miles of country. Small beds of clay with rock-salt are also found: the whole is said to resemble the paraffin and salt districts of Galicia. The paraffin shale is free from bituminous impurities. It contains :—

Paraffin wax	1·75 per cent.
Water of combination	3·02 ,,
Ammonia	1·18 ,,

The mineral constituents of the shale are :—

Alumina	32·86 per cent.
Iron oxide	5·20 ,,
Magnesia	1·26 ,,
Lime...	1·21 ,,
Potash	2·17 ,,
Soda...	0·41 ,,
Silica	56·85 ,,
Loss...	0·04 ,,
	100·00

The brown coal of the neighbourhood, whose natural distillation has most probably yielded the hydrocarbon in the shales, contains:—

Carbon	49·2 per cent.
Hydrogen	1·1 ,,
Water, combined	30·2 ,,
Water, hygroscopic	19·5 ,,
	100·00

The beds containing these coals have been invaded by eruptive porphyry and trachytic rocks, of which the former contains 75½ and the latter 61 per cent. of silica.

The clays from which the shales were originally formed contain abundance of marine Diatomaceæ and Foraminifera (chiefly Nummulites), as also species of *Ostrea*, *Cyrena*, *Cerithium*, *Voluta*, and *Nautilus*, together with the remains of Placoid and Teleostean fishes.

CORRESPONDENCE.

WATER-BEARING NODULES IN THE LOWER GREENSANDS.

Sir,—The brilliant and varied colouring of the Lower Greensands at the Great Northern Railway at Sandy Junction, and at Flitwick Station on the Midland line, must be familar to every one who has travelled those districts. At Sandy, the cutting is a deep one and nearly all in clean sand, varying through shades of green, grey and yellow, the yellow predominating, to almost pure white. At Flitwick, the colouring is still more varied; beautifully tinted bands of a fleshy pink or salmon tint, merging into violet, appear near the bottom of the pit from which Mr. Franklin, of Bedford, obtains his sand. The parti-coloured bands are more numerous at this place than I recollect seeing elsewhere in Bedfordshire, although the white and yellow sand at Heath and Reach, makes very picturesque openings amongst the woods and ferns. The sands at Flitwick remind one of the assemblage of colours met with in the sands,[1] from which the well-known sand pictures are made in the Isle of Wight.

But besides the varied colouring, ironstone nodules, associated with hard lumps of ferruginous rock, like the carstone quarried at Snettisham in Norfolk, are very general in the Greensand. Being of all shapes and sizes and in every stage of growth, they are curious to look upon, and still more interesting to crack for the fossils and sparry crystals that are sometimes found inside them. An abundance of these concretions occurs both at Sandy and Flitwick, some spherical, others tabular, and many other forms.

With Rhodes, the fossil collector, I have lately obtained a number of these nodules from Flitwick,[2] some of which, for description sake, and from the fact of their having water in them, I have designated water-bearing nodules. These are readily distinguished from others inclosing phosphatized fossils (principally the internal casts of some

[1] Bagshot Sands.

[2] From the peat at Flitwick I picked out, last year, a small flint implement.

species of oyster), by being audibly full of water when shaken. Many contain only sand, lime or earthy matter, perhaps the residue of fossils destroyed.

Collecting the water-bearing nodules is somewhat akin to choosing cocoa-nuts at the greengrocer's. We pick up one after the other from the ground, rejecting the light ones, and those that give forth no sound, in favour of those which, like the cocoa-nuts with milk, bear unmistakeable evidence of containing liquid.

What the nature of this liquid may be,[1] or what duration of time has elapsed since it was sealed up in these portable reservoirs, is not for me at present to say, having as yet made no minute examination. The specimens contained water when we picked them up, as did others when split with the hammer. Since bringing them home, they have been in a warm room, and the water from some reason, probably increased temperature, has evaporated or disappeared. The iron pan which forms the walls of the cavity may be porous, and I have placed them in a vessel of water, expecting them to become water-bearing nodules again; the phenomenon would then be probably explained, by supposing that during periods of wet these nodules absorb the water percolating through the Greensand.

It then becomes a question whether these nodules may not be a cause of diminution in the water supply? in districts where they are largely developed. But against the absorption theory, remains the fact that the weather was very warm and fine when the nodules were gathered, and the recent heavy rains had not set in.[2]

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ON THE TERM NEOCOMIAN.

Sir,—In writing his article upon the above subject, in the last Number of the Geological Magazine, my friend Mr. Jukes-Browne appears to have been labouring under a curious and very unfortunate misconception. He says :—

"For many years English geologists were content with the nomenclature employed by the earlier students of the Cretaceous system—Webster, Murchison, Mantell and Fitton. In 1864, however, the French term Neocomian was introduced by Prof. Judd, who adopted it for the Cretaceous portion of the Speeton Clay, and Sir Charles Lyell subsequently used it as a synonym for the whole Lower Cretaceous series in England, as distinct from the Upper Cretaceous series or the beds lying above the Lower Greensand."

Through the whole of the following pages, the writer of the article enlarges upon this text, treating myself as responsible for the error,

[1] Since writing the above, it has been suggested to me that an analysis of the water might be made. This would of course be a valuable guide to the source of supply.—A. G. C.

[2] For a description of the mode of formation of the ironstone concretions, see Penning, Geol. Mag. Dec. II. Vol. III. p. 218. Geology of Cambridge, Geological Survey Memoir, p. 12, Penning and Jukes-Browne.

as he regards it, of introducing the term Neocomian into English geological literature.

Now what are the real facts of the case? For the last forty or fifty years the term Neocomian has been quite commonly applied, by many eminent English geologists, to a part or to the whole of the Lower Greensand, and even those who are prepared to credit me with the most phenomenal precocity, could scarcely charge me with leading astray my fathers in science so long ago as that. The author who had the chief honour, as I esteem it, of introducing the term to English science was the late Mr. R. A. C. Godwin-Austen, and his practice dates at least as far back as the year 1843. If my friend Mr. Jukes-Browne will refer to several memoirs by that author—such as those "On the Geology of the South-East of Surrey" (Proc Geol. Soc. vol. iv. (1843), pp. 167–173, 196–198); "On the Age and Position of the Fossiliferous Sands and Gravels of Farringdon" (Quart. Journ. Geol. Soc. vol. vi. (1851), pp. 454–478); and "On the Possible Extension of the Coal-measures beneath the South-Eastern part of England" (Quart. Journ. Geol. Soc. vol. xii. (1856), pp. 38–73)—he will find that Mr. Austen not only uniformly employs the term Neocomian for a part at least of the Lower Greensand, but that he defends his practice by some very judicious and cogent arguments. If the writer of the article will look through the contemporary geological literature in this country, he will also find that the example of Mr. Godwin-Austen was followed by other geologists of high reputation.

Of course Mr. Godwin-Austen—who happened to have a remarkably extensive acquaintance with continental geology—was well aware of the fact referred to by Mr. Jukes-Browne, that at Neuchatel there is no exact representative of our Lower Greensand; but Mr. Godwin-Austen's arguments, based on the fact that the fossils of our English formation (or at least of the lower part of it) are very similar to those of the Neocomian, while they are on the whole very different from those of the Upper Cretaceous, have always seemed to me to be worthy of the most careful consideration; and many other geologists, I find, have acknowledged their weight by following his example.

My own part in connection with this question was very different from what my friend supposes; it consisted in describing a series of strata, in Lincolnshire and Yorkshire, which are for the most part older than the Lower Greensand, and correspond in age with strata on the Continent which all geologists, including Mr. Jukes-Browne, agree in calling Neocomian. At the same time, as I have already stated in a paper in this Journal (Geol. Mag. Vol. VII. 1870, p. 220), I have always regarded Mr. Godwin-Austen's proposal to extend the use of the term as originally defined, so as to include the English Lower Greensand, to be much more logical and defensible than that of M. D'Orbigny—which was to restrict the name to one part of the series.

Considering, as I do, the Neocomian to be a great continuous

system of strata, with no very important breaks in it, the conventional limits which are to be adopted for the Upper, Middle and Lower divisions, respectively, appear to me to be a question of by no means great importance. At the same time, any attempt to disturb, without very good cause shown, names which have come into general use, or to alter the definition of terms which have been generally accepted—whether the attempt be made by officers of the Geological Survey, in their individual or their corporate capacity—will, I strongly suspect, prove a hopeless, as I am sure that it is a useless, task. Consequently, I trust the idea of "formulating a new nomenclature" as the result of "the revision by the members of the Geological Survey" of the Cretaceous rocks of England, is one that will, in moments of calmer reflection, be abandoned. Scientific names go through a "struggle for existence," and the fittest survive. I trust my friend Mr. Jukes-Browne will draw a moral from the fact, that the name Neocomian has shown a very considerably greater vitality than he seems to have suspected.

But while Mr. Jukes-Browne gives me credit for that of which I cannot possibly accept the honour, he himself assumes a responsibility which, it seems to me, he is not called upon to bear. In speaking of "the merits of the name (*Vectian*) which I have already proposed as a substitute for Lower Greensand," he must surely have forgotten a well-known passage in the works of Dr. Fitton. After remarking that he had long since stated his objections to the use of the term Lower Greensand, that author writes as follows:—"If hereafter a change be thought desirable, he conceives that the new denomination should be taken from the *Isle of Wight*, where this portion of the sub-cretaceous groups was first distinguished, and where the sections on the coast are remarkable for their distinctness; and if such a case should arise, he suggests the name *Vectine* for the strata now called Lower Green Sand, from the ancient name of that island,—*Insula Vectis* of the Romans" (Quart. Journ. Geol. Soc. 1845, vol. i. p. 189).

As the paper in which this passage occurs was read in 1844 and published in 1845, it seems to me scarcely more likely that Mr. Jukes-Browne could have offered useful hints on the subject to Fitton than that I was engaged in a previous year in improperly influencing Godwin-Austen.

JOHN W. JUDD.

ERUPTION OF MOUNT TARAWERA, NORTH ISLAND, NEW ZEALAND.—A most destructive volcanic outburst occurred on the night of the 9th of June, from Tarawera, a mountain not more than 3000 feet high, which rises near the lake of the same name, and about nine miles from Rotomahana. At two o'clock a shock of greater violence occurred followed by a terrific roar, a pillar of light shot up from the summit of Tarawera, molten lava and hot mud were rained abroad, while huge rocks were thrown up and around in all directions. Showers of hot cinders and boiling mud covered the settlement of Wairoa, killing on the spot or burying alive numbers of persons. For sixty miles the destruction has spread. About 100 persons have perished, whilst villages and settlements are covered with eight or ten feet of mud or ashes. We hope to give a fuller account in our next number.